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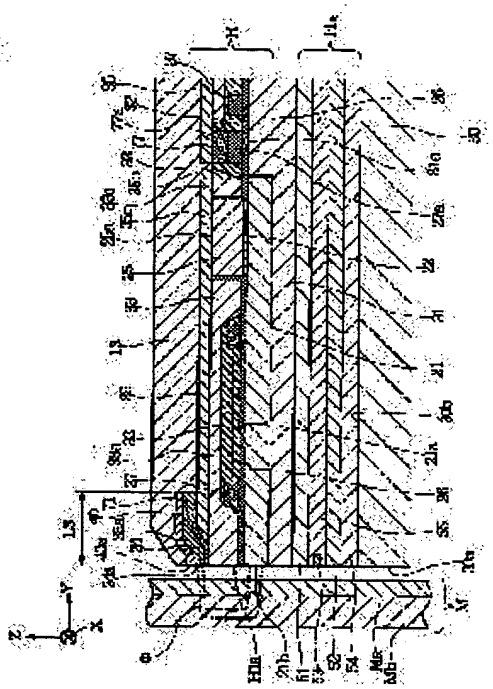
(54) PERPENDICULAR MAGNETIC RECORDING HEAD AND ITS MANUFACTURING METHOD

(57)Abstract:

PROBLEM TO BE SOLVED: To provide a perpendicular magnetic recording head capable of properly forming plated main magnetic pole layer from an insulating layer to a yoke layer, and increasing the passing efficiency of a magnetic flux from the yoke layer to the main magnetic pole layer, and its manufacturing method.

SOLUTION: The front end surface 35a of a yoke layer 35 is formed to be a slant or a bent surface inclined from a lower surface to an upper surface in a height direction. Thus, the main magnetic pole layer 24 is properly plated and formed in a specified shape, and the passing efficiency of the magnetic flux from the yoke layer 35 to the main magnetic pole layer 24 is increased. Therefore, a perpendicular magnetic recording head capable of dealing with a higher recording density is manufactured.



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* NOTICES *

1. This document has been translated by computer.So the translation may not reflect the original precisely.
2. **** shows the word which can not be translated.
3.In the drawings, any words are not translated.

CLAIMS

[Claim(s)]
[Claim 1] An auxiliary magnetic pole layer and a main pole layer open an interval in an opposed face with a record medium, and are located in it. By the perpendicular magnetic field which the coil layer which gives a record magnetic field to the aforementioned auxiliary magnetic pole layer and the aforementioned main pole layer is prepared in the height direction back rather than the aforementioned opposed face, and is concentrated on the aforementioned main pole layer In the vertical-magnetic-recording head which records magnetic data on the aforementioned record medium The connection layer which starts from the aforementioned auxiliary magnetic pole layer rather than the aforementioned opposed face in the height direction back is prepared. Winding formation of the aforementioned coil layer is carried out around the aforementioned connection layer, and the aforementioned coil layer top is covered by the insulating layer. on the aforementioned insulating layer The yoke layer made into the inclined plane or curve side which the front end side by the side of the aforementioned opposed face is located in the height direction back, and the aforementioned front end side is moreover missing from the upper surface from the undersurface, and inclines in the height direction is formed. The end face section of the aforementioned yoke layer is a vertical-magnetic-recording head characterized by connecting with the aforementioned connection layer magnetically, applying on the aforementioned yoke layer from on the insulating layer in the aforementioned opposed face, and forming the main pole layer.
[Claim 2] The upper surface of the aforementioned insulating layer and the upper surface of the aforementioned connection layer are a vertical-magnetic-recording head according to claim 1 used as the flattening side made into the same side.
[Claim 3] The front end side of the aforementioned main pole layer which has appeared in the aforementioned opposed face is a vertical-magnetic-recording head according to claim 1 or 2 currently formed in the configuration in which the width-of-face size of the direction of the width of recording track spreads towards the upper surface from the undersurface.
[Claim 4] The both-sides end face of the aforementioned front end side is a vertical-magnetic-recording head according to claim 3 currently formed in respect of the inclined plane or the curve.
[Claim 5] A vertical-magnetic-recording head according to claim 1 to 4 with the saturation magnetic flux density of the aforementioned main pole layer higher than the saturation magnetic flux density of the aforementioned yoke layer.
[Claim 6] The cross section from a direction parallel to the aforementioned opposed face of the aforementioned yoke layer in the position with which the aforementioned yoke layer and a main pole layer lap is a larger vertical-magnetic-recording head according to claim 1 to 5 than the cross section from a direction parallel to the aforementioned opposed face of the aforementioned main pole layer.
[Claim 7] The manufacture method of the vertical-magnetic-recording head characterized by having the following processes.
(a) It is the process which forms an auxiliary magnetic pole layer by the magnetic material, and on the (b) aforementioned auxiliary magnetic pole layer. The process which fills the aforementioned coil layer top by the insulating layer after forming a connection layer in the height direction back and forming [rather than an opposed face with a record medium] a coil layer through an insulating ground layer between the aforementioned opposed face and a connection layer on the aforementioned auxiliary magnetic pole layer next, (c) The process which deletes the front face of the aforementioned insulating layer and makes the same field the aforementioned insulating-layer upper surface and the aforementioned connection layer upper surface, (d) The process which forms in the aforementioned insulating-layer upper surface and the connection layer upper surface the plating ground layer of the yoke layer configuration where a front end side is located in the height direction back rather than the aforementioned opposed face, and is prolonged even on the aforementioned connection layer, (e) The process which carries out plating formation of the yoke layer by the magnetic material on the aforementioned plating ground layer, and is made into the inclined plane or curve side

which inclines in the height direction, applying the front end side of the aforementioned yoke layer to the upper surface from the undersurface at this time, (f) The process which keeps being prolonged in the aforementioned resist layer even from the insulating layer in the aforementioned opposed face to on the aforementioned yoke layer, and forms a pattern after forming a plating ground layer on the aforementioned insulating layer and a yoke layer and forming a resist layer on the aforementioned plating ground layer, (g) Process which removes the aforementioned resist layer after carrying out plating formation of the main pole layer by the magnetic material on the aforementioned plating ground layer exposed in the aforementioned omission pattern.

[Claim 8] The manufacture method of the vertical-magnetic-recording head according to claim 7 which forms a plating ground layer at the following processes in the aforementioned (d) process.

(h) The process which forms a plating ground layer in the aforementioned insulating-layer upper surface and the connection layer upper surface, and forms a resist layer on the aforementioned plating ground layer further, (i) The process which leaves the resist layer of the yoke layer configuration where a front end side is located in the height direction back rather than the aforementioned opposed face, and is prolonged even on the aforementioned connection layer, and removes other resist layers, and process which removes the aforementioned resist layer after removing the plating ground layer which is not covered by (j) resist layer.

[Claim 9] The manufacture method of the vertical-magnetic-recording head according to claim 7 which forms a plating ground layer at the following processes in the aforementioned (d) process.

(k) The process which the yoke layer configuration which a resist layer is formed in the aforementioned insulating-layer upper surface and the connection layer upper surface, and a front-end side is further located in the height direction back rather than the aforementioned opposed face at the aforementioned resist layer, and is prolonged even on the aforementioned connection layer extracts, and forms a pattern in the aforementioned resist layer, and the process which remove the aforementioned resist layer after carrying out the spatter membrane formation of the plating ground layer into the (l) aforementioned omission pattern.

[Claim 10] The manufacture method of the vertical-magnetic-recording head according to claim 7 to 9 which the inside width method of the direction of the width of recording track in the aforementioned opposed face is missing from the upper surface, keeps spreading from the undersurface at least in the aforementioned (f) process, and forms a pattern in the aforementioned resist layer.

[Claim 11] The manufacture method of a vertical-magnetic-recording head according to claim 7 to 11 of removing the aforementioned plating ground layer which is the aforementioned (g) process and was formed [except, under the aforementioned main pole layer] further.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] this invention relates to the vertical-magnetic-recording head which records by giving a perpendicular magnetic field to record media, such as a disk which has a hard film, especially it can carry out plating formation appropriately, applying a main pole layer on a yoke layer from on an insulating layer, and relates to the vertical-magnetic-recording head which can moreover raise the passage efficiency of the magnetic flux from the aforementioned yoke layer to a main pole layer, and its manufacture method.
[0002]
[Description of the Prior Art] There is vertical magnetic recording as equipment which records magnetic data on record media, such as a disk, by high density. Drawing 27 is the cross section showing the general structure of the vertical-magnetic-recording head used for the equipment of the aforementioned vertical magnetic recording.
[0003] As shown in drawing 27 , the vertical-magnetic-recording head H of vertical magnetic recording is formed in the side edge side of the slider 1 which moves [surfaces it and] or slides on a record-medium top, and the aforementioned vertical-magnetic-recording head H is arranged between a nonmagnetic membrane 2 and the nonmagnetic covering film 3 in side edge side 1a of a slider 1.
[0004] The aforementioned vertical-magnetic-recording head H has the auxiliary magnetic pole layer 4 formed with a ferromagnetic material, and the main pole layer 5 which opened the interval and was formed on the aforementioned auxiliary magnetic pole layer 4 and which was similarly formed with a ferromagnetic material, and end-face 4a of the aforementioned auxiliary magnetic pole layer 4 and end-face 5a of the aforementioned main pole layer 5 have appeared in the opposed face Ha with a record medium M. In the back side, the aforementioned auxiliary magnetic pole layer 4 and the aforementioned main pole layer 5 are magnetically connected in the magnetic connection 6 rather than the aforementioned opposed face Ha.
[0005] Between the aforementioned auxiliary magnetic pole layer 4 and the aforementioned main pole layer 5, the nonmagnetic insulating layer 7 by inorganic material, such as aluminum2O3 and SiO2, is located, and end-face 7a of this nonmagnetic insulating layer 7 has appeared in the aforementioned opposed face Ha between end-face 4a of the aforementioned auxiliary magnetic pole layer 4, and end-face 5a of the aforementioned main pole layer 5.
[0006] And in the aforementioned nonmagnetic insulating layer 7, the coil layer 8 formed with conductive material, such as Cu, is laid underground.
[0007] As shown in drawing 27 , the thickness hw of end-face 5a of the main pole layer 5 is smaller than the thickness hr of end-face 4a of the auxiliary magnetic pole layer 4. Moreover, as shown in the plan of drawing 28 , the width-of-face size of end-face 5a of the direction of the width of recording track of the aforementioned main pole layer 5 (the direction of illustration X) is the width of recording track Tw, and this width-of-face size is smaller enough than the width-of-face size Wr of end-face 4a of the direction of the width of recording track of the aforementioned auxiliary magnetic pole layer 4.
[0008] The record medium M to which magnetic recording is performed by the aforementioned vertical-magnetic-recording head H moves to a Z direction to the vertical-magnetic-recording head H, and the soft film Mb is formed for the hard film Ma in the front face in the inner direction.
[0009] When are energized by the aforementioned coil layer 8 and a record magnetic field is guided to the auxiliary magnetic pole layer 4 and the main pole layer 5, the leakage record magnetic field between end-face 4a of the auxiliary magnetic pole layer 4 and end-face 5a of the main pole layer 5 passes the hard film Ma of a record medium M perpendicularly, and passes along the soft film Mb. Here, since the area of end-face 5a of the main pole layer 5 is smaller enough than the area in end-face 4a of the auxiliary magnetic pole layer 4 as mentioned above, magnetic flux phi concentrates in the opposite portion of end-face 5a of the main pole layer 5, and magnetic data are recorded by the

aforementioned magnetic flux phi to the aforementioned hard film Ma in the portion which end-face 5a counters.
[0010] By the way, as shown in the plan of drawing 28 , the aforementioned main pole layer 5 consists of front field 5c of **** by which linear dimension was formed in the height direction back by L1 from the aforementioned opposed face Ha, and yoke section 5b to which it applies to the height direction back from the end face of the aforementioned front field 5c, and the width-of-face size of the direction of the width of recording track (the direction of illustration X) spreads on a target gradually.
[0011] Forming as short as possible can ease the magnetic saturation in the aforementioned front field 5c, it can concentrate and generate the magnetic flux which flows from aforementioned yoke section 5c from front end side 5a of the aforementioned main pole layer 5, and the linear dimension L1 of the aforementioned front field 5c has it.
[desirable]
[0012] However, if the aforementioned linear dimension L1 is shortened too much, it is difficult to form the minute pattern of front field 5c correctly. As the width of recording track Tw of the aforementioned front end side 5a spreads, and is formed from a predetermined value or it is shown in drawing 28 The width-of-face size of the direction of the width of recording track (the direction of illustration X) will spread, and will be formed as it goes in the height direction (the direction of illustration Y), and control of the configuration of the width of recording track Tw and the aforementioned front field 5c was very difficult.
[0013] The problem of such configuration change has the large place which front field 5c of the aforementioned main pole layer 5 and yoke section 5b depend on the monolayer formed in one, and the structure where the aforementioned front field 5c forms yoke section 5b independently for this reason is considered.
[0014] Drawing 29 is drawing of longitudinal section which improved the conventional vertical-magnetic-recording head shown in drawing 27 , and as shown in drawing 29 , the yoke layer 10 is formed on the nonmagnetic insulating layer 7. Front end side 10a of the aforementioned yoke layer 10 is located in the height direction (direction of illustration Y) back from the aforementioned opposed face Ha, moreover, starts from the nonmagnetic insulating layer 7 to a perpendicular, and is formed. Moreover, as shown in drawing 29 , it applies on the aforementioned yoke layer 10 from on the nonmagnetic insulating layer 7 in the aforementioned opposed face Ha, and the main pole layer 5 is formed. As the plan of the vertical-magnetic-recording head shown in drawing 29 is a flat-surface configuration like drawing 30 and is shown in drawing 30 The aforementioned yoke layer 10 is a configuration to which the width-of-face size of the direction of the width of recording track (the direction of illustration X) spreads on a target gradually as it goes in the height direction (the direction of illustration Y). the aforementioned main pole layer 5 It consists of 5d of back fields in which the width-of-face size from the end face of width-of-face narrow type-like front field 5c in which front end side 5a was formed by the width of recording track Tw, and this front field 5c to the direction of the width of recording track spreads.
[0015] Even if it forms the linear dimension L2 to the height direction (the direction of illustration Y) of front field 5c of the aforementioned main pole layer 5 on the aforementioned yoke layer 10 like drawing 29 and 30 for a long time than before as it is the structure of piling up the main pole layer 5 By bringing near and forming the aforementioned yoke layer 10 in an opposed face Ha side as much as possible, the magnetic flux from the aforementioned yoke layer 10 can be appropriately led to front field 5c of the aforementioned main pole layer 5, without the aforementioned front field 5c reaching magnetic saturation.
[0016] Thus, since front field 5c of the aforementioned main pole layer 5 was formed in the height direction for a long time as it is the structure shown in drawing 30 , pattern precision improved and it was thought that the aforementioned front field 5c could be formed in the predetermined width of recording track Tw and a predetermined, predetermined configuration.
[0017]
[Problem(s) to be Solved by the Invention] However, with the vertical-magnetic-recording head shown in drawing 29 , since front end side 10a of the aforementioned yoke layer 10 rises from the upper surface of the nonmagnetic insulating layer 7 to a perpendicular and is formed, a big level difference is formed between the aforementioned nonmagnetic insulating layer 7 and the aforementioned front end side 10a. For this reason, the following problems occurred at the time of the formation process of the aforementioned main pole layer 5. Drawing 31 and drawing 32 are 1 process drawings showing the manufacture method at the time of forming the aforementioned main pole layer 5.
[0018] As shown in drawing 31 , the yoke layer 10 is formed on the aforementioned nonmagnetic insulating layer 7, it applies on the aforementioned yoke layer 10 from on the aforementioned nonmagnetic insulating layer 7 further, and the plating ground layer 11 is formed. This plating ground layer 11 is a ground for carrying out plating growth of the main pole layer 5 at the following process. Furthermore, the resist layer 12 is formed on the aforementioned plating ground layer 11.
[0019] As shown in drawing 31 , since front end side 10a of the aforementioned yoke layer 10 rises from on the

nonmagnetic insulating layer 7 to a perpendicular and is formed, between the aforementioned front end side 10a and the nonmagnetic insulating layer 7, the big level difference A produces it.
[0020] For this reason, a size difference arises from on the aforementioned nonmagnetic insulating layer 7 in the thickness H2 of the resist layer 12 applied to the resist layer 12 applied on the yoke layer 10, applying on the aforementioned yoke layer 10, and the thickness H3 of the resist layer 12 applied on the aforementioned nonmagnetic insulating layer 7.
[0021] Although it extracts for main pole layer 5 formation in the aforementioned resist layer 12 and pattern 12a is formed in exposure development in the process shown in following drawing 32 Since the thickness of the aforementioned resist layer 12 becomes thick rapidly in the portion of the aforementioned level difference A to the resist layer 12 on the yoke layer 10 at this time, Exposure is not made suitable even for the inferior surface of tongue of the resist layer 12 applied to the portion of this level difference A, but resist layer 12b by which exposure development is not carried out tends to remain in the portion of the aforementioned level difference A.
[0022] And even if it is going to carry out plating growth of the main pole layer 5 from on the plating ground layer 11 exposed in the aforementioned omission pattern 12a next If resist layer 12b remains in the aforementioned omission pattern 12a, since the plating ground layer 11 is covered by the aforementioned resist layer 12b in the portion, plating growth is not made appropriately. On the aforementioned resist layer 12b, the main pole layer 5 of extremely thin thickness is formed, or a defective is easy to be formed -- the main pole layer 5 is not formed in this portion at all.
[0023] Moreover, if there is a big level difference A and a big difference is in the thickness of the resist layer 12 between the yoke layer 10 and the nonmagnetic insulating layer 7, since the pattern precision of the aforementioned omission pattern 12a falls, it cannot form front field 5c of the aforementioned main pole layer 5 in the predetermined width of recording track Tw and a predetermined, predetermined configuration, and cannot manufacture the vertical-magnetic-recording head which can respond to ** truck-ization.
[0024] Moreover, the front-end side 10a of the aforementioned yoke layer 10 rises from on a nonmagnetic insulating layer 7 to a perpendicular, if the aforementioned yoke layer 10 is formed by the shape of an abbreviation rectangle in the position which laps with the aforementioned main pole layer 5, magnetic flux will become easy to leak from front-end side 10a of the aforementioned yoke layer 10, the aforementioned magnetic flux will not be drawn suitable for the main pole layer 5 from the aforementioned yoke layer 10, but the passage efficiency of magnetic flux will fall, and the fall
[0025] Then, it aims at offering the vertical-magnetic-recording head which plating formation can be carried out appropriately, this invention being able to solve the above-mentioned conventional technical problem, and being able to apply the aforementioned main pole layer on the aforementioned yoke layer from on an insulating layer by making the front end side of the aforementioned yoke layer into a gently-sloping inclined plane or a curve side, and can raise the passage efficiency of the magnetic flux from the aforementioned yoke layer to a main pole layer, and its manufacture method.
[0026]
[Means for Solving the Problem] An auxiliary magnetic pole layer and a main pole layer open an interval in an opposed face with a record medium, and this invention is located in it. By the perpendicular magnetic field which the coil layer which gives a record magnetic field to the aforementioned auxiliary magnetic pole layer and the aforementioned main pole layer is prepared in the height direction back rather than the aforementioned opposed face, and is concentrated on the aforementioned main pole layer In the vertical-magnetic-recording head which records magnetic data on the aforementioned record medium The connection layer which starts from the aforementioned auxiliary magnetic pole layer rather than the aforementioned opposed face in the height direction back is prepared. Winding formation of the aforementioned coil layer is carried out around the aforementioned connection layer, and the aforementioned coil layer top is covered by the insulating layer. on the aforementioned insulating layer The yoke layer made into the inclined plane or curve side which the front end side by the side of the aforementioned opposed face is located in the height direction back, and the aforementioned front end side is moreover missing from the upper surface from the undersurface, and inclines in the height direction is formed. It is characterized by connecting the end face section of the aforementioned yoke layer with the aforementioned connection layer magnetically, applying on the aforementioned yoke layer from on the insulating layer in the aforementioned opposed face, and forming the main pole layer.
[0027] In this invention, the inclined plane or curve side which is missing from the upper surface from the undersurface, and inclines in the height direction is formed in the front end side of the aforementioned yoke layer.
[0028] Thus, if not the configuration in which the front end side of the aforementioned yoke layer starts as a vertical plane in this invention unlike the former but the aforementioned front end side is the configuration which starts towards the height direction in respect of a gently-sloping inclined plane or a curve The resist layer used when

applying on a yoke layer from on the insulating layer located ahead of the aforementioned yoke layer and forming a main pole layer can be formed by almost uniform thickness. Therefore, it is formed in the aforementioned resist layer and extracts, and it applies to the undersurface, and exposure development is carried out appropriately and the resist layer in a pattern can be removed from the upper surface. Therefore, since the plating ground layer for resist **** not occurring but forming a main pole layer in the aforementioned omission pattern like before in this invention at the aforementioned whole surface in an omission pattern can be exposed, it is possible to carry out plating formation of the aforementioned main pole layer appropriately in a predetermined configuration into the aforementioned omission pattern.

[0029] Moreover, it is possible to form a main pole layer since thickness of the resist layer applied on the yoke layer from the aforementioned insulating layer which starts gently-sloping so that thickness may become [the front-end side of the aforementioned yoke layer from the aforementioned insulating layer] large gradually as mentioned above in this invention, and is used in the case of main pole layer formation is mostly made to regularity with a sufficient pattern precision, and it is easy to form the front-end side of the aforementioned main pole layer with high precision [in the predetermined width of recording track Tw and a predetermined configuration]

[0030] Moreover, in this invention, if it is a gently-sloping inclined plane or a curve side so that the front end side of the aforementioned yoke layer may apply in the height direction and thickness may become thick gradually, the magnetic flux from the aforementioned yoke layer is smoothly led to a main pole layer, and can suppress the leakage of the magnetic flux from the aforementioned front end side conventionally. That is, since the passage efficiency of the magnetic flux from the aforementioned yoke layer to a main pole layer can be raised in this invention and magnetic flux can be centralized on the aforementioned main pole layer, it is possible to manufacture the vertical-magnetic-recording head excellent in high recording density-ization.

[0031] Moreover, as for the upper surface of the aforementioned insulating layer, and the upper surface of the aforementioned connection layer, in this invention, it is desirable that it is the flattening side made into the same side. Thereby, a yoke layer and a main pole layer can be formed with a sufficient pattern precision.

[0032] Moreover, as for the front end side of the aforementioned main pole layer which has appeared in the aforementioned opposed face in this invention, it is desirable to be formed in the configuration in which the width-of-face size of the direction of the width of recording track spreads towards the upper surface from an inferior surface of tongue, and, as for the both-sides end face of the aforementioned front end side, in this case, it is desirable to be formed in respect of an inclined plane or a curve.

[0033] Moreover, in this invention, it is desirable that the saturation magnetic flux density of the aforementioned main pole layer is higher than the saturation magnetic flux density of the aforementioned yoke layer. In this invention, the aforementioned main pole layer and a yoke layer can be formed separately. For this reason, it is possible for it to be able to become possible to choose a magnetic material with saturation magnetic flux density higher than a yoke layer as the aforementioned main pole layer, to be able to make the aforementioned main pole layer collect magnetic flux by this, and to manufacture the vertical-magnetic-recording head which can respond suitable for a raise in recording density.

[0034] Moreover, as for the cross section from a direction parallel to the aforementioned opposed face of the aforementioned yoke layer in the position with which the aforementioned yoke layer and a main pole layer lap in this invention, it is desirable that it is larger than the cross section from a direction parallel to the aforementioned opposed face of the aforementioned main pole layer. It is possible to raise the passage efficiency of the magnetic flux from the aforementioned yoke layer to a main pole layer by this.

[0035] Moreover, the manufacture method of the vertical-magnetic-recording head in this invention is characterized by having the following processes.

(a) It is the process which forms an auxiliary magnetic pole layer by the magnetic material, and on the (b) aforementioned auxiliary magnetic pole layer. The process which fills the aforementioned coil layer top by the insulating layer after forming a connection layer in the height direction back and forming [rather than an opposed face with a record medium] a coil layer through an insulating ground layer between the aforementioned opposed face and a connection layer on the aforementioned auxiliary magnetic pole layer next, (c) The process which deletes the front face of the aforementioned insulating layer and makes the same field the aforementioned insulating-layer upper surface and the aforementioned connection layer upper surface, (d) The process which forms in the aforementioned insulating-layer upper surface and the connection layer upper surface the plating ground layer of the yoke layer configuration where a front end side is located in the height direction back rather than the aforementioned opposed face, and is prolonged even on the aforementioned connection layer, (e) The process which carries out plating formation of the yoke layer by the magnetic material on the aforementioned plating ground layer, and is made into the inclined plane or curve side which inclines in the height direction, applying the front end side of the aforementioned yoke layer to the upper surface

from an inferior surface of tongue at this time, (f) The process which keeps being prolonged in the aforementioned resist layer even from the insulating layer in the aforementioned opposed face to on the aforementioned yoke layer, and forms a pattern after forming a plating ground layer on the aforementioned insulating layer and a yoke layer and forming a resist layer on the aforementioned plating ground layer, (g) Process which removes the aforementioned resist layer after carrying out plating formation of the main pole layer by the magnetic material on the aforementioned plating ground layer exposed in the aforementioned omission pattern.

[0036] In this invention, the plating ground layer for the yoke stratification is formed on an insulating layer at the aforementioned (d) process, and plating growth of the yoke layer is carried out on the aforementioned plating ground layer at the aforementioned (e) process. At the aforementioned (d) process, the circumference of the aforementioned plating ground layer It is not surrounded by the resist layer etc. but only the plating ground layer is formed on the insulating layer by which flattening was carried out. Thus, the front end side of the yoke layer which carries out plating growth from a plating ground layer without the enclosure by the resist layer etc. grows being roundish, and can be formed in respect of the inclined plane which inclines in the height direction, applying the front end side of the aforementioned yoke layer to the upper surface from an inferior surface of tongue, or a curve.

[0037] And in this invention, since the front end side of the aforementioned yoke layer is a gently-sloping inclined plane or a curve side, thickness of the resist layer formed on a yoke layer from on the insulating layer ahead of the aforementioned yoke layer at the above-mentioned (f) process, applying can be mostly made into homogeneity.

[0038] For this reason, when a main pole layer extracts in the aforementioned resist layer and a pattern is formed in exposure development, it applies throughout the upper surface, and exposure development is carried out appropriately, the resist layer in the aforementioned omission pattern can be removed from an inferior surface of tongue, and resist **** does not occur like before in the aforementioned omission pattern.

[0039] Therefore, it is possible for the plating ground layer for the main pole stratification to be appropriately exposed in the aforementioned omission pattern, therefore to carry out plating growth of the main pole layer appropriately with a predetermined configuration on the aforementioned plating ground layer at the aforementioned (g) process.

[0040] Moreover, it is desirable to form a plating ground layer at the following processes in the aforementioned (d) process in this invention.

(h) The process which forms a plating ground layer in the aforementioned insulating-layer upper surface and the connection layer upper surface, and forms a resist layer on the aforementioned plating ground layer further, (i) The process which leaves the resist layer of the yoke layer configuration where a front end side is located in the height direction back rather than the aforementioned opposed face, and is prolonged even on the aforementioned connection layer, and removes other resist layers, and process which removes the aforementioned resist layer after removing the plating ground layer which is not covered by (j) resist layer.

[0041] Or in this invention, you may form a plating ground layer at the following processes in the aforementioned (d) process.

(k) The process which the yoke layer configuration which a resist layer is formed in the aforementioned insulating-layer upper surface and the connection layer upper surface, and a front-end side is further located in the height direction back rather than the aforementioned opposed face at the aforementioned resist layer, and is prolonged even on the aforementioned connection layer extracts, and forms a pattern in the aforementioned resist layer, and the process which remove the aforementioned resist layer after carrying out the spatter membrane formation of the plating ground layer into the (l) aforementioned omission pattern.

[0042] According to the formation method of the above-mentioned plating ground layer, the circumference of the aforementioned plating ground layer is not surrounded in a resist layer etc., but only the aforementioned insulating layer has become an extended state to the circumference of the aforementioned plating ground layer. Therefore, if plating growth of the yoke layer is carried out on the aforementioned plating ground layer, the circumference of the aforementioned yoke layer grows being roundish, and can be formed as the inclined plane which inclines in the height direction, applying the front end side of the aforementioned yoke layer to the upper surface from an inferior surface of tongue, or a curve side.

[0043] Moreover, it is desirable for the inside width method of the direction of the width of recording track in the aforementioned opposed face to be missing from the upper surface, to keep spreading from an inferior surface of tongue at least, in the aforementioned (f) process, in this invention, and to form a pattern in the aforementioned resist layer.

[0044] It can form in the configuration in which this applies the front end side of the aforementioned main pole layer to the upper surface from an inferior surface of tongue, and a width-of-face size spreads gradually.

[0045] Moreover, it is desirable to remove the aforementioned plating ground layer which is the aforementioned (g) process and was formed [except under the aforementioned main pole layer] further by this invention.

[0046]
[Embodiments of the Invention] Drawing 1 is drawing of longitudinal section showing the structure of the magnetic head equipped with the vertical-magnetic-recording head of the 1st operation gestalt of this invention.
[0047] The vertical-magnetic-recording head H shown in drawing 1 gives a perpendicular magnetic field to a record medium M, and makes the hard film Ma of a record medium M magnetize perpendicularly.
[0048] The aforementioned record medium M is a disk-like, and the high hard film Ma of residual magnetization has the soft film Mb with magnetic high permeability in the inner direction, and the center of a disk takes the axis-of-rotation lead, and it is rotated for it by the front face.
[0049] If it is formed with ceramic material, such as aluminum 2O3 and TiC, opposed face 30a of a slider 30 counters the aforementioned record medium M and a record medium M rotates, a slider 30 will surface from the front face of a record medium M by the surface airstream, or a slider 30 will slide on the slider 30 of the aforementioned vertical-magnetic-recording head H at a record medium M. In drawing 1 , the move direction of the record medium M to a slider 30 is an illustration Z direction. The aforementioned perpendicular magnetic-head H is prepared in the trailing side edge side of a slider 30.
[0050] The nonmagnetic insulating layer 54 by inorganic material, such as aluminum 2O3 or SiO2, is formed in side edge side 30b of the aforementioned slider 30, and read station HR is formed on this nonmagnetic insulating layer.
[0051] The aforementioned read station HR consists of the lower shell lower shield layer 52, the gap layer 55, the magnetoresistance-effect element 53, and the up shield layer 51. The aforementioned magnetoresistance-effect elements 53 are an anisotropy magnetoresistance-effect (AMR) element, a huge magnetoresistance-effect (GMR) element, a tunneled type magnetoresistance-effect (TMR) element, etc.
[0052] On the aforementioned up shield layer 51, the nonmagnetic insulating layer 31 by inorganic material, such as aluminum 2O3 or SiO2, is formed, and the vertical-magnetic-recording head H for record of this invention is formed on the aforementioned nonmagnetic insulating layer 31. And the vertical-magnetic-recording head H is covered with the protective layer 13 formed by the inorganic nonmagnetic insulating material etc. And opposed face H1a with the record medium of the aforementioned vertical-magnetic-recording head H is the same side mostly with opposed face 30a of the aforementioned slider 30.
[0053] Ferromagnetic material, such as a permalloy (nickel-Fe), is plated with the aforementioned vertical-magnetic-recording head H, and the auxiliary magnetic pole layer 21 is formed with it. In addition, the aforementioned up shield layer 51 may be made to serve a double purpose as the aforementioned auxiliary magnetic pole layer 21. The aforementioned nonmagnetic insulating layer 31 is formed in the bottom of the aforementioned auxiliary magnetic pole layer 21 (between the auxiliary magnetic pole layer 21 and side edge side 30b of a slider 30), and the circumference of the aforementioned auxiliary magnetic pole layer 21. And as shown in drawing 1 , surface (upper surface) 21a of the auxiliary magnetic pole layer 21 and surface (upper surface) 31a of the aforementioned nonmagnetic insulating layer 31 are located on the same flat surface.
[0054] As shown in drawing 1 , the connection layers 25, such as nickel-Fe, are formed on surface 21a of the aforementioned auxiliary magnetic pole layer 21 rather than the aforementioned opposed face H1a in the height direction back (the direction of illustration Y).
[0055] In the circumference of the aforementioned connection layer 25, the insulating ground layers 26, such as aluminum 2O3, are formed on surface 21a of the aforementioned auxiliary magnetic pole layer 21, and surface 31a of the aforementioned nonmagnetic insulating layer 31, and the coil layer 27 is formed of conductive material, such as Cu, on this insulating ground layer 26. This coil layer 27 is formed with frame plating etc., and pattern formation is spirally carried out so that it may become a predetermined number of turns around the aforementioned connection layer 25. On end-connection 27a by the side of the volume center of the coil layer 27, the bottom raising layer 77 similarly formed with conductive material, such as Cu, is formed.
[0056] The aforementioned coil layer 27 and the bottom raising layer 77 are covered with the insulating layer 32 of organic materials, such as resist material, and are further covered by the insulating layer 33.
[0057] As for the aforementioned insulating layer 33, being formed by the inorganic insulating material is desirable, and at least one or more sorts in AlO, aluminum 2O3, SiO2 and Ta 2O5, TiO and AlN, AlSiN, TiN and SiN, Si3N4, NiO, WO, WO3, BN and CrN, and SiON can be chosen as the aforementioned inorganic insulating material.
[0058] And surface (upper surface) 25a of the aforementioned connection layer 25, surface (upper surface) 77a of the bottom raising layer 77, and surface (upper surface) 33a of an insulating layer 33 are processed so that it may become the same side. Such flattening processing is performed using CMP technology etc. so that it may explain by the below-mentioned manufacture method.
[0059] With this 1st operation form, the yoke layer 35 is formed on the aforementioned insulating layer 33. As shown in drawing 1 , front end side 35a of the aforementioned yoke layer 35 is formed in the height direction (direction of

illustration Y) back rather than the aforementioned opposed face H1a. Moreover, end face section 35c of the aforementioned yoke layer 35 is formed in the upper surface of the aforementioned connection layer 25, and the aforementioned end face section 35c and the connection layer 25 will be magnetically connected. Since the insulating layer 33 under the aforementioned yoke layer 35 is formed in respect of flattening, the aforementioned yoke layer 35 can be formed with a sufficient pattern precision.

[0060] Moreover, in this invention, it is the inclined plane or curve side which inclines in the height direction (the direction of illustration Y), front end side 35 applying [of the aforementioned yoke layer 35] it to the upper surface from the undersurface (illustration Z direction).

[0061] Moreover, as shown in drawing 1 , the lead layer 36 is formed in surface 77a of the aforementioned bottom raising layer 77, and supply of record current is possible in the aforementioned bottom raising layer 77 and the coil layer 27 from the lead layer 36. In addition, it can form with the same material as the aforementioned yoke layer 35, and the aforementioned lead layer 36 can form simultaneously the aforementioned yoke layer 35 and the lead layer 36 by plating.

[0062] Moreover, as shown in drawing 1 , the main pole layer 24 which applied on the aforementioned yoke layer 35 from on the insulating layer 33 located in the aforementioned opposed face H1a side, and was formed by magnetic materials, such as NiFe, through the plating ground layer 71 rather than the aforementioned yoke layer 35 is formed. Furthermore, the non-magnetic layer 40 is piled up and formed on the aforementioned main pole layer 24. And both the front end sides 24a and 40a of the aforementioned main pole layer 24 and a non-magnetic layer 40 have appeared from aforementioned opposed face H1a.

[0063] In addition, with the operation form shown in drawing 1 , although formed by the linear dimension of L3, applying the aforementioned main pole layer 24 and the yoke layer 35 in the height direction from aforementioned opposed face H1a, if the aforementioned main pole layer 24 and the yoke layer 35 lap partly and are connected magnetically, the aforementioned linear dimension L3 will not be limited. Therefore, the aforementioned main pole layer 24 and a non-magnetic layer 40 may be formed in the height direction still longer, for example, may be extended like drawing 2 to the same position as back end side 35b of the aforementioned yoke layer 35.

[0064] In addition, as shown in drawing 1 and 2, the aforementioned non-magnetic layer 40 and yoke layer 35 top is covered by the aforementioned protective layer 13.

[0065] In addition, if the non-magnetic layer 40 has piled up on the main pole layer 24 like drawing 1 and drawing 2 At the time of the process which removes the plating ground layer 71 formed [except under the aforementioned main pole layer 24] Although the component of the aforementioned plating ground layer 71 may adhere to the both-sides end face of the direction of the width of recording track of the aforementioned main pole layer 24 (the direction of illustration X) when the aforementioned plating ground layer 71 can be removed and the aforementioned plating ground layer 71 is removed, without decreasing the height size of the aforementioned main pole layer 24 Even in this case, the aforementioned adhesion film can be removed, without decreasing the height size of the aforementioned main pole layer 24. Moreover, although the width of recording track Tw of the aforementioned main pole layer 24 can be narrowed and the vertical-magnetic-recording head which can respond to ** truck-ization can be manufactured by deleting the both-sides end face of the aforementioned main pole layer 24, it is possible to attain ** truck-ization of the aforementioned main pole layer 24, without decreasing the height size of the aforementioned main pole layer 24 also in this time.

[0066] In addition, as for the aforementioned non-magnetic layer 40, being formed with non-magnetic metal material is desirable. NiP, NiCu, NiMn, and NiW, NiB, Pd, Rh, Ru, Au and Cu can be chosen as the aforementioned non-magnetic metal material. It is desirable to choose NiP also in this. In addition to the continuation plating ease on manufacture, the aforementioned non-magnetic layer 40 is excellent in thermal resistance in it being NiP, and its adhesion with the main pole layer 24 is also good. Moreover, hardness with the main pole layer 24 and the amount of processings of a non-magnetic layer 40 and the main pole layer 24 by the ion milling later mentioned since it is equivalent can be made equivalent, and can raise processability.

[0067] Moreover, a non-magnetic layer 40 is a NiP alloy, and it is [the concentration of Element P] desirable that it is below 15 mass % above 8 mass %. It is stabilized also, for example to external factors, such as generation of heat, by this, and it is possible for it to be nonmagnetic. Moreover, measurement of alloy composition of the non-magnetic layers 40, such as a NiP alloy, can be specified with an X-rays spectroscopic analyzer, wave distributed line analysis equipment, etc. which were put [transverse electromagnetic / SEM,] together.

[0068] In addition, the reason for choosing the above-mentioned non-magnetic metal material is that the plating formation of the aforementioned non-magnetic layer 40 can be carried out in succession on the main pole layer 24 by which plating formation is carried out, and it can attain simplification of a manufacturing process.

[0069] Drawing 3 is drawing of longitudinal section of the magnetic head which equipped the vertical-magnetic-

recording head which shows another operation form in this invention.
[0070] A non-magnetic layer 40 puts the operation form of drawing 3 on the difference in drawing 1 , and the upper surface of the aforementioned main pole layer 24, and it is not prepared in them. for this reason, although the effect by having formed the above-mentioned non-magnetic layer 40 cannot be acquired in drawing 3 , it is formed in respect of the inclined plane which inclines in the height direction (the direction of illustration Y), applying front end side 35a of the aforementioned yoke layer 35 to the upper surface from the undersurface also in this operation form, or a curve, and what the effect of this invention mentioned later is acquired for is possible
[0071] Next, the configuration of the front end sides 24a and 40a of the main pole layer 24 in drawing 1 and drawing 2 and a non-magnetic layer 40 is explained.
[0072] As shown in drawing 4 and 5, the plating ground layer 71 is formed between the aforementioned insulating layer 33 and the main pole layer 24. From the aforementioned plating ground layer 71, the aforementioned main pole layer 24 carries out plating growth, and is formed, and the height size H1 of the aforementioned main pole layer 24 is set as a certain predetermined value.
[0073] As shown in drawing 4 and 5, the both-sides end faces 24d and 24d of front end side 24a of the aforementioned main pole layer 24 are formed in the configuration in which is followed toward the upper surface (illustration Z direction) from the undersurface, and the width-of-face size of the direction of the width of recording track (the direction of illustration X) spreads gradually. As for the aforementioned both-sides end faces 24d and 24d, it is desirable like drawing 4 to be formed in respect of a curve as shown in an inclined plane or drawing 5 .
[0074] The width-of-face size of the direction of the width of recording track is formed in the configuration which spreads gradually as are furthermore shown in drawing 4 and 5 and front end side 40a of the non-magnetic layer 40 formed on the aforementioned main pole layer 24 also goes to the upper surface from the undersurface. Moreover, as shown in drawing 4 and 5, the both-sides end faces 40d and 40d of the aforementioned front end side 40a are made into the both-sides end faces 24d and 40d and continuation side of the aforementioned main pole layer 24, and, therefore, 40d of both-sides end faces of front end side 40a of the aforementioned yoke layer 40 is an inclined plane by drawing 4 , and 40d of both-sides end faces of the aforementioned front end side 40a is a curve side in drawing 5 .
[0075] In addition, as shown in drawing 4 and 5, the width of recording track Tw is regulated with the width-of-face size of the direction of the width of recording track of 24g of upper surfaces of the aforementioned main pole layer 24 (end face by the side of trailing).
[0076] In addition, when the non-magnetic layer 40 has not piled up on the aforementioned main pole layer 24 like drawing 3 , front end side 24a of the aforementioned main pole layer 24 is a configuration in which it applies to the upper surface from the undersurface, and the width-of-face size of the direction of the width of recording track (the direction of illustration X) spreads gradually, and, as for the both-sides end faces 24d and 24d of the aforementioned front end side 24a, it is desirable at this time that they are an inclined plane or a curve side.
[0077] Thus, when actually recording on a record medium that the both-sides end faces 24d and 24d of front end side 24a of the aforementioned main pole layer 24 are made into an inclined plane or a curve side, and the configuration of the aforementioned front end side 24a is a **** trapezoidal shape, The 24d of the aforementioned end faces shown by (iii) though an angle of skew is produced as the dashed line of drawing 10 shows does not overflow aslant the recording track width of face Tw1 into the side greatly. Therefore, fringing by the 24d of the aforementioned both-sides end faces can be prevented now, and improvement in an off-track performance can be aimed at.
[0078] On the other hand, although drawing 33 is the front view of the conventional main pole layer 5 shown in drawing 27 or drawing 29 If end-face 5a of the aforementioned main pole layer 5 is a square or a rectangle like drawing 33 If end-face 5a of the main pole layer 5 has an angle of skew to the move tangential direction (illustration Z direction) of a record medium, as a dashed line shows, side side 5b of a main pole layer will give a slanting leakage magnetic field into the width of recording track Tw1, Fringing F will occur, and off-track performance degradation will be caused.
[0079] Therefore, as for front end side 24a of the aforementioned main pole layer 24, it is good like this invention that it is a **** trapezoidal shape.
[0080] Next, the aforementioned main pole layer 24 and the yoke layer 35 are explained below about the flat-surface configuration seen from right above. In addition, the plan explained below is applicable to all of the vertical-magnetic-recording head shown in drawing 1 or drawing 3 .
[0081] As shown in the plan of drawing 6 , the aforementioned yoke layer 35 is a flat-surface configuration to which the width-of-face size Wy of the direction of the width of recording track becomes thin at 35d of front fields which are the opposed face H1a side, and the width-of-face size of the direction of the width of recording track becomes large gradually by back field 35e. And the main pole layer 24 has piled up on the 35d of the aforementioned front fields. In addition, the width-of-face size Wy in the direction of the width of recording track of the 35d of the aforementioned

front fields (the direction of illustration X) is formed with a width-of-face size larger than the width of recording track Tw.

[0082] As shown in drawing 6 , the upper surface (end face by the side of trailing) of front end side 24a is regulated by the width of recording track Tw, and the aforementioned main pole layer 24 maintains the width-of-face size, or becomes a little broad, and is formed by short linear dimension towards the height direction back.

[0083] In addition, in this invention, it is required for front end side 24a of the aforementioned main pole layer 24 exposed to the aforementioned opposed face H1a to be larger than the area of front end side 21b of the aforementioned auxiliary magnetic pole layer 21, for example, as shown in drawing 6 , it is desirable [the width-of-face size Wr of the direction of the width of recording track of the auxiliary magnetic pole layer 21] to be formed with a width-of-face size larger enough than the aforementioned width of recording track Tw.

[0084] In drawing 7 , the width-of-face size Wy is the configuration which spreads gradually as it results in the height direction (the direction of illustration Y), without the aforementioned yoke layer 35 having the 35d of the aforementioned front fields. And the main pole layer 24 has piled up on the aforementioned yoke layer 35.

[0085] As shown in drawing 7 , the upper surface (end face of trailing side **) of front end side 24a is regulated by the width of recording track Tw, and the aforementioned main pole layer 24 maintains the width-of-face size, or becomes a little broad, and is formed by short linear dimension towards the height direction back.

[0086] In drawing 8 , although the configuration of the aforementioned yoke layer 35 is the same as drawing 7 , back field 24e of the aforementioned main pole layer 24 is the configuration in which a width-of-face size spreads gradually, and this back field 24e and the yoke layers 35 overlap. However, the aforementioned yoke layer 35 is further come together and formed in opposed face side H1a, and 24f of a part of front fields of the shape of a width-of-face narrow type of the aforementioned main pole layer 24 may overlap the aforementioned yoke layer 35. Introduction of the magnetic flux from the aforementioned yoke layer 35 to the aforementioned main pole layer 24 can be made smooth by this, and the vertical-magnetic-recording head which can respond to high recording density-ization can be manufactured.

[0087] Moreover, 35d of front fields as shown in the aforementioned yoke layer 35 at drawing 6 may be formed.

[0088] Back field 24e of the aforementioned main pole layer 24 is the configuration in which a width-of-face size spreads gradually, and although the configuration of the aforementioned yoke layer 35 is the same as drawing 7 and drawing 8 , further, in drawing 9 , this back field 24e is prolonged in the height direction (the direction of illustration Y) for a long time, and is formed in it by it. The back end of the aforementioned back field 24e may be extended like drawing 2 by even the same field as back end side 35b of the aforementioned yoke layer 35.

[0089] Moreover, 35d of front fields as shown in the aforementioned yoke layer 35 at drawing 6 may be formed. Furthermore, back field 24e to which a width-of-face size spreads on a target gradually is not formed in the aforementioned main pole layer 24, the width of recording track Tw is maintained at it towards the height direction, or mist and 24f of front fields of **** which became broad may be extended for a long time in the height direction from the aforementioned width of recording track Tw towards the height direction.

[0090] With the plan shown in above-mentioned drawing 6 or above-mentioned drawing 9 , the field where the width-of-face size Wy spreads on a target gradually is formed as each results in the height direction at the aforementioned yoke layer 35, and in the position with which the aforementioned yoke layer 35 and the main pole layer 24 lap especially, the width-of-face size of the direction of the width of recording track of the aforementioned yoke layer 35 is larger than the width-of-face size of the direction of the width of recording track of the aforementioned main pole layer 24.

[0091] Moreover, the thickness of the aforementioned yoke layer 35 is of the same grade as the thickness of the aforementioned main pole layer 24, or the thickness of the aforementioned yoke layer 35 is formed more greatly than the thickness of the aforementioned main pole layer 24.

[0092] Therefore, in the position with which the aforementioned yoke layer 35 and the main pole layer 24 lap, the cross section to a direction parallel to the aforementioned opposed face H1a of the aforementioned yoke layer 35 is larger than the cross section to a direction parallel to the aforementioned opposed face H1a of the aforementioned main pole layer 24. A record magnetic field can be drawn suitable for the aforementioned main pole layer 24 from the aforementioned yoke layer 35 by this, and the passage efficiency of magnetic flux becomes good and can improve an over-writing property.

[0093] Moreover, the main pole layer 24 and the yoke layer 35 are separately formed like drawing 1 or drawing 3 , the direction which extends 24f of front fields formed by **** of the aforementioned main pole layer 24 for a long time, and forms them when it is the structure of piling up the main pole layer 24 on the aforementioned yoke layer 35 can form mostly the width-of-face size of the whole of the 24f of the aforementioned front fields with a sufficient pattern precision by the width of recording track Tw, and it is desirable. When starting furthermore, by bringing near and

forming the aforementioned yoke layer 35 in the opposed face H1a side as much as possible, the magnetic saturation of the aforementioned main pole layer 24 can be suppressed, and magnetic flux can be centralized on the aforementioned main pole layer 24.

[0094] In addition, drawing 6 or drawing 9 is an example, and the flat-surface configuration of the main pole layer 24 and the yoke layer 35 is not limited to these flat-surfaces configuration. By this invention, in the position with which the aforementioned main pole layer 24 and the yoke layer 35 lap, as long as the cross section to a direction parallel to the aforementioned opposed face H1a of the aforementioned yoke layer 35 is larger than the cross section to a direction parallel to the aforementioned opposed face H1a of the aforementioned main pole layer 24, it may be formed in what flat-surface configuration.

[0095] By the way, in this invention, front end side 35a of the aforementioned yoke layer 35 is formed also in drawing 1 or which operation form of drawing 3 in respect of the inclined plane which is missing from the upper surface from the undersurface, and inclines in the height direction, or the curve.

[0096] About the formation method of such front end side 35a, although explained in detail by the next manufacture method, thereby, the following effects can be acquired.

[0097] Namely, although it extracts for main pole layer 24 formation in the aforementioned resist layer and a pattern is formed by exposure development in this invention when forming the main pole layer 24 formed on the aforementioned yoke layer 35 from on the insulating layer 33 located ahead rather than the aforementioned yoke layer 35, applying using a resist layer under the present circumstances, since the resist layer which applies that front end side 35a of the aforementioned yoke layer 35 is a gently-sloping inclined plane or a curve side on the yoke layer 35 from on the aforementioned insulating layer 33, and is formed can be formed by the thickness of about 1 law The exposure development of the resist layer in the aforementioned omission pattern can be appropriately carried out from the upper surface to the undersurface, and resist **** does not occur in the aforementioned omission pattern like before.

[0098] Therefore, in this invention, the plating ground layer 71 can be exposed on the aforementioned whole surface in an omission pattern, and plating growth of the main pole layer 24 of a predetermined configuration can be carried out appropriately on the aforementioned plating ground layer 71.

[0099] Moreover, it is possible to be able to raise pattern precision, since the thickness of the resist layer for forming the aforementioned main pole layer 24 can be mostly formed in homogeneity, if front end side 35a of the aforementioned yoke layer 35 is formed in respect of the gently-sloping inclined plane or the curve as mentioned above, therefore to form the aforementioned main pole layer 24 with a sufficient pattern precision.

[0100] It enables especially front end side 24a that appears in the aforementioned opposed face H1a of the aforementioned main pole layer 24 as described above to set up this width of recording track Tw with a predetermined size with high precision, although the size of the direction of the width of recording track of the upper surface (end face by the side of trailing) is regulated as the width of recording track Tw. Therefore, in this invention, the vertical-magnetic-recording head which can respond to ** truck-ization can be manufactured.

[0101] Moreover, in this invention, by front end side 35a of the aforementioned yoke layer 35 being a gently-sloping inclined plane or a curve side, magnetic flux is smoothly led to the aforementioned main pole layer 24 from the aforementioned yoke layer 35, and the passage efficiency of magnetic flux can be raised. That is, in this invention, the magnetic flux which leaks from front end side 35a of the aforementioned yoke layer 35 can be decreased, magnetic flux can be centralized suitable for the aforementioned main pole layer 24, and the vertical-magnetic-recording head which can respond can be manufactured suitable for the future formation of high record dense.

[0102] Moreover, in this invention, as described above, upper surface 33a of the aforementioned insulating layer 33 and upper surface 25a of the connection layer 25 are the flattening side made into the same field by CMP technology etc.

[0103] Therefore, it enables yoke layer 35 further to form the main pole layer 24 with a sufficient pattern precision on the aforementioned insulating layer 33.

[0104] Moreover, since it is possible to form separately the aforementioned main pole layer 24 and the yoke layer 35 in this invention, it is also possible to form the aforementioned main pole layer 24 and the yoke layer 35 at a different magnetic material. It is desirable in this case, to choose a magnetic material so that the saturation magnetic flux density of the aforementioned main pole layer 24 may become higher than the saturation magnetic flux density of the yoke layer 35. If the main pole layer 24 is formed by the magnetic material with saturation magnetic flux density higher than the yoke layer 35, it will become possible from the small main pole layer 24 of the width-of-face size Tw and thickness to give the magnetic flux phi with high density perpendicularly to the hard film Ma, and an over-writing property will come to improve.

[0105] In addition, although magnetic materials, such as nickel-Fe, Co-Fe, and nickel-Fe-Co, are chosen as the aforementioned main pole layer 24 and the yoke layer 35, when choosing the same magnetic material as the main pole

layer 24 and the yoke layer 35, it is possible to take out a difference with changing a composition ratio to saturation magnetic flux density.

[0106] In addition, with the vertical-magnetic-recording head shown in drawing 1 or drawing 3 , if record current is given to the coil layer 27 through the lead layer 36, a record magnetic field will be guided to the auxiliary magnetic pole layer 21 and the yoke layer 35 by the current magnetic field of the current which flows the coil layer 27. As shown in drawing 1 or 3, in opposed face H1a, the leakage record magnetic field from front end side 24a of the aforementioned main pole layer 24 and front end side 21b of the auxiliary magnetic pole layer 21 penetrates the hard film Ma of a record medium M, and passes the soft film Mb. Since the area of front end side 24a of the aforementioned main pole layer 24 is smaller enough than the area of front end side 21b of the auxiliary magnetic pole layer 21, it leaks to front end side 24a of the aforementioned main pole layer 24, the magnetic flux phi of a record magnetic field concentrates, the aforementioned hard film Ma is perpendicularly magnetized by this magnetic flux phi currently concentrated, and magnetic data are recorded.

[0107] Next, the manufacture method of the vertical-magnetic-recording head of this invention is explained below. Drawing 11 to drawing 26 is process drawing showing the manufacturing process of the vertical-magnetic-recording head in this invention. In addition, drawing 13 shows the manufacturing process with the common vertical-magnetic-recording head shown in drawing 1 or drawing 3 from drawing 11 .

[0108] At the process shown in drawing 11 , after forming the auxiliary magnetic pole layer 21 made from a magnetic material on the nonmagnetic insulating layer 31, the height direction (direction of illustration Y) back of the aforementioned auxiliary magnetic pole layer 21 is also fill uped with the aforementioned nonmagnetic insulating layer 31, and carries out flattening processing of the upper surface of the aforementioned auxiliary magnetic pole layer 21 and the nonmagnetic insulating layer 31 using CMP technology etc. further.

[0109] Next, behind [height direction (direction of illustration Y)] the aforementioned auxiliary magnetic pole layer 21, plating formation of the connection layer 25 made from a magnetic material is carried out, it applies to the upper surface of the connection layer 25 from the auxiliary magnetic pole layer 21 aforementioned upper surface further, the spatter of the inorganic insulating material is carried out, and the insulating ground layer 26 is formed in it.

[0110] Next, as shown in drawing 12 , the coil layer 27 is formed with frame plating on the aforementioned insulating ground layer 26, and similarly the bottom raising layer 77 is further formed by plating. The coil layer 27 is formed in a position lower enough than the height of the aforementioned connection layer 25 at this time. And the aforementioned coil layer 27 and the bottom raising layer 77 are covered by the insulating layer 32 of an organic material, further, the spatter of the inorganic insulating material is carried out, and the wrap insulating layer 33 is formed for all layers.

[0111] Next, polish processing is performed from the illustration upper part to each class formed by the state of drawing 12 using CMP technology etc. This polish processing is performed to the position of the level surface (L-L side) which crosses all the aforementioned insulating layers 33, the connection layers 25, and bottom raising layers 77.

[0112] As a result of the aforementioned polish processing, as shown in drawing 13 , it is processed so that all of surface 25a of the connection layer 25, surface 33a of an insulating layer 33, and surface 77a of the bottom raising layer 77 may become the same field.

[0113] It is the manufacturing process in which even this is common in each operation form. Next, the manufacture method of the vertical-magnetic-recording head of the structure shown in drawing 1 is explained.

[0114] Drawing 14 is a plan and carries out spatter membrane formation of the plating ground layer 72 all over the upper [of the insulating layer 33 by which flattening was carried out]. Next, the resist layer 80 is formed on the aforementioned plating ground layer 72, it leaves pattern 80a of yoke layer 35 configuration to the aforementioned resist layer 80, and the other resist layer is removed. In addition, since there was a thing by which it shall not be exposure-development-removed according to the kind of resist layer 80 in the portion by which exposure development was carried out and from which a portion is removed, when the resist layer 80 from which the portion by which exposure development was carried out is removed is used, exposure development is carried out in resist layers 80 other than the aforementioned pattern 80a, and the portion is removed. Moreover, when the resist layer 80 from which the portion by which exposure development is not carried out is removed is used, exposure development of the inside of the aforementioned pattern 80a is carried out, and the resist layer 80 by which exposure development is not carried out is removed. It can leave the resist layer 80 of pattern 80a shown in drawing 14 by this.

[0115] In addition, the aforementioned pattern 80a is located yoke pattern 80c and behind the field in which the yoke layer 35 is formed, and consists of common pattern 80d for plating energization.

[0116] In addition, as for the aforementioned pattern 80a, the front end side 80b is located in the height direction (direction of illustration Y) back rather than the aforementioned opposed face H1a, and yoke pattern 80c of the aforementioned pattern 80a is prolonged and formed even in the aforementioned connection layer 25.

[0117] Next, after removing the plating ground layer 72 which is not covered by the aforementioned resist layer 80 by

ion milling, the aforementioned resist layer 80 is removed.
[0118] On the aforementioned insulating layer 33, the plating ground layer 72 of the configuration of pattern 80a is left behind by this.
[0119] Next, drawing 15 is a plan and covers aforementioned common pattern 80d top in the resist layer 76 in this process. Drawing of longitudinal section at this time is shown in drawing 18 . And plating growth of the yoke layer 35 is carried out on the plating ground layer 72 of the aforementioned yoke pattern 80c.
[0120] Or you may form the yoke layer 35 by the following method. Drawing 16 is a plan and forms the resist layer 73 on the aforementioned insulating layer 33 at this process. Furthermore, it keeps becoming the aforementioned resist layer 73 with the flat-surface configuration of the yoke layer 35, and pattern 73a is formed by exposure development. The aforementioned omission pattern 73a consists of yoke pattern 73c of the field in which the yoke layer 35 is formed, and common pattern 73d for plating energization located in the back. As for the aforementioned omission pattern 73a, the front end side 73b is located in the height direction (direction of illustration Y) back rather than the aforementioned opposed face H1a, and yoke pattern 73c of the aforementioned omission pattern 73a is prolonged and formed even in the aforementioned connection layer 25.
[0121] And spatter membrane formation of the plating ground layer 72 is carried out into the aforementioned omission pattern 73a, and the aforementioned resist layer 73 is removed.
[0122] In the process shown in drawing 17 , aforementioned common pattern 73d top is covered in the resist layer 74. Drawing of longitudinal section at this time is shown in drawing 18 . And plating growth of the yoke layer 35 is carried out on the plating ground layer 72 formed on the aforementioned yoke pattern 73c which is not covered by the aforementioned resist layer 74.
[0123] Next, if the aforementioned resist layers 76 and 74 are removed after drawing 15 and the drawing 17 process and the plating ground layer 72 on common pattern 80d and 73d is removed further, drawing of longitudinal section of the vertical-magnetic-recording head in this time will become like drawing 19 .
[0124] As shown in drawing 19 , the front end side 35a is roundish [wore gently-sloping], or the yoke layer 35 by which plating formation was carried out on the aforementioned plating ground layer 72 serves as a gently-sloping inclined plane. Thus, it is because, as for the aforementioned front end side 35a becoming a gently-sloping inclined plane or a curve side, the circumference of the plating ground layer 72 on the aforementioned yoke pattern 73c is not surrounded by the resist layer etc. at the time of drawing 15 or the drawing 17 process but the circumference of the aforementioned yoke pattern 73c is opened wide.
[0125] When drawing 15 and drawing 17 , or drawing 18 is looked at in detail, it turns out that the circumference of the plating ground layer 72 formed on the aforementioned insulating layer 33 is not surrounded by the resist layers 74 and 76 etc. except for common pattern 75d top.
[0126] Thus, when the circumference of the aforementioned plating ground layer 72 is not surrounded and is wide opened by the resist layer etc., the end face of the yoke layer 35 which carries out plating growth on the aforementioned plating ground layer 72 grows being roundish gently-sloping, and turns into an inclined plane or a curve side.
[0127] In addition, in this invention, if the front field is not covered by the resist layer at least rather than front end side 72b of the aforementioned plating ground layer 72, it is good, for example, the both-sides end face in the direction of the width of recording track of the aforementioned plating ground layer 72 (the direction of illustration X) may be worn by the resist layer. In this case, the yoke layer 35 at least which carries out plating growth on the aforementioned plating ground layer 72 is formed as the inclined plane which the front end side 35a is missing from the upper surface from the undersurface, and inclines in the height direction, or a curve side.
[0128] Moreover, although not shown in drawing 19 , it is desirable to carry out plating formation of the lead layer 36 at the time of the process shown also in upper surface 77a of the aforementioned bottom raising layer 77 at drawing 14 or drawing 17 and the same process.
[0129] Next, at this process, it is a plan, drawing 20 carries out spatter membrane formation of the plating ground layer 71 on the insulating layer 33 which spreads to the aforementioned yoke layer 35 and its circumference, forms the resist layer 75 on it, is extracted for formation of the main pole layer 24 in the aforementioned resist layer 75, and forms pattern 75a by exposure development.
[0130] As shown in drawing 20 , front end side 75b of the aforementioned omission pattern 75a is formed on the same field as the aforementioned opposed face H1a, and the aforementioned omission pattern 75a is further prolonged and formed even on the aforementioned yoke layer 35. Moreover, at this process, the aforementioned omission pattern 75a may be further prolonged and formed in the height direction (direction of illustration Y) back, as 75d of the back end side shows with an alternate long and short dash line.
[0131] Moreover, drawing 21 is drawing of longitudinal section which cut the vertical-magnetic-recording head from

the M-M line shown in drawing 20 , and was seen from the arrow.
[0132] As shown in drawing 21 , it extracts, and there is no resist **** into pattern 75a like before, and it will be formed in the aforementioned resist layer 75.
[0133] This is because front end side 35a of the aforementioned yoke layer 35 is a gently-sloping inclined plane or a curve side as mentioned above. Thickness of the resist layer 75 formed on the yoke layer 35 from on the front insulating layer 33 rather than the aforementioned yoke layer 35 by this, applying is mostly made to homogeneity. The thing which is formed in the aforementioned resist layer 75 and which extracts, carry out exposure development appropriately and removes the resist layer 75 in pattern 75a from the upper surface to the undersurface is possible.
[0134] Next, if the aforementioned resist layer 75 in this invention is seen from the aforementioned opposed face H1a side, it serves as a configuration shown in drawing 22 .
[0135] As shown in drawing 22 , it was formed in the aforementioned resist layer 75, and extracts, and it applies to the upper surface from the undersurface (illustration Z direction), and the width-of-face size of the direction of the width of recording track (the direction of illustration X) spreads gradually, and the inside end faces 75e and 75e of pattern 75a are formed. The aforementioned inside end-face 75e may be formed in respect of the curve, as shown in drawing 22 , and it may be formed in the inclined plane.
[0136] In order for such a configuration to extract and to form pattern 75a in the aforementioned resist layer 75, after applying the aforementioned resist layer 75, the aforementioned omission pattern 75a is formed in exposure development, it is making inside side 75e of the aforementioned omission pattern 75a flag with heat treatment further, and the aforementioned inside side 75e can be formed in an inclined plane or a curve side.
[0137] Next, as shown in drawing 23 and 24, plating growth of the main pole layer 24 is carried out on the aforementioned plating ground layer 71 exposed in the aforementioned omission pattern 75a. At this time, plating growth of the aforementioned main pole layer 24 is carried out to a certain predetermined thickness H1 like drawing 23 .
[0138] Furthermore by this invention, plating growth of the non-magnetic layer 40 which consists of non-magnetic metal material, such as NiP, on the aforementioned main pole layer 24 is carried out. And the aforementioned resist layer 75 is removed.
[0139] In this invention, as seen in drawing 21 , there is no resist **** into the aforementioned omission pattern 75a, and the plating ground layer 71 will be exposed suitable for the aforementioned whole surface in omission pattern 75a. Therefore, it is possible for plating growth of the aforementioned main pole layer 24 to be appropriately carried out from the aforementioned plating ground layer 71, and to form the aforementioned main pole layer 24 of a predetermined configuration.
[0140] Moreover, the main pole layer 24 formed on the aforementioned yoke layer 35 since the aforementioned resist layer 75 can be formed by almost uniform thickness in this invention when front end side 35a of the aforementioned yoke layer 35 is a gently-sloping inclined plane or a curve side extracts, and it is a pattern formation plain-gauze cone with high precision about pattern 75a.
[0141] Although especially the size of the direction of the width of recording track of the upper surface (end face by the side of trailing) of front end side 24a of the aforementioned main pole layer 24 is regulated as the minute width of recording track Tw, it is possible to be able to form the aforementioned width of recording track Tw in a predetermined size, and to manufacture the vertical-magnetic-recording head which can respond to future ** truck-ization with a pattern precision high as mentioned above.
[0142] Drawing 25 is the front view showing the state where the aforementioned resist layer 75 was removed. As shown in drawing 25 , on the aforementioned plating ground layer 71, the width-of-face size of the direction of the width of recording track is missing from the upper surface from the undersurface, and the laminating of the main pole layer 24 and non-magnetic layer 40 by which the both-sides end face was made the inclined plane or the curve side so that it might spread gradually is carried out.
[0143] Since the aforementioned plating ground layer 71 is formed not only in the bottom of the aforementioned main pole layer 24 but in other fields as shown in drawing 25 , you have to remove the aforementioned plating ground layers 71 other than under the main pole layer 24.
[0144] At the process shown in drawing 25 , the ion milling of an anisotropy removes the aforementioned plating ground layer 71 formed [except under the aforementioned main pole layer 24]. At this time, upper surface 40e of the aforementioned non-magnetic layer 40 is also deleted in response to the influence of the aforementioned ion milling.
[0145] Moreover, as shown in drawing 26 , since a part of removed aforementioned plating ground layer 71a re-adheres to the both-sides end faces 24d and 40d of the aforementioned main pole layer 24 and a non-magnetic layer 40 (the direction C of an arrow), it removes the adhesion films 78 and 78 adhering to the aforementioned both-sides end face by the ion milling of an anisotropy. Also at this time, as for upper surface 40e of the aforementioned non-magnetic

layer 40, it is deleted in response to the influence of the aforementioned ion milling. In addition, removal of the aforementioned plating ground layer 71 and the adhesion film 78 is effective especially when the aforementioned plating ground layer 71 is formed by the magnetic material. It is because the width of recording track Tw spreads that the aforementioned adhesion film 78 is a magnetic material. On the other hand, when the aforementioned adhesion film 78 is nonmagnetic plating material, especially removal of the aforementioned adhesion film 78 is unnecessary. Moreover, especially when the aforementioned plating ground layer 71 is formed within limits which do not affect an electrical property, removal of the aforementioned plating ground layer 71 is also unnecessary.

[0146] As mentioned above, by this invention, since the non-magnetic layer 40 is formed on the main pole layer 24, when removing the plating ground layer 71 and its adhesion film 78 by ion milling, the height size H1 of the aforementioned main pole layer 24 does not decrease only by the ability to delete upper surface 40e of the aforementioned non-magnetic layer 40.

[0147] moreover -- the case where the width of recording track Tw which deletes further 24d of both-sides end faces of the aforementioned main pole layer 24 and 40d of both-sides end faces of a non-magnetic layer 40 by the ion milling of an anisotropy, and is decided by the width-of-face size of 24g of upper surfaces of the aforementioned main pole layer 24 (end face by the side of trailing) is made small -- Io -- although upper surface 40e of a non-magnetic layer 40 is deleted by milling, the height size H1 of the aforementioned main pole layer 24 does not decrease

[0148] Therefore, when the non-magnetic layer 40 is piled up and formed on the main pole layer 24 like this invention, it is in the state which the height size H1 of the main pole layer 24 was not decreased, and was maintained at constant value, and it is possible to realize removal of plating ground layer 71a and the adhesion film 78 and ** truck-ization.

[0149] In addition, as for the aforementioned ion milling, in this invention, it is desirable to be carried out at the angle which inclined before and after 45 degrees to 70 degrees perpendicularly to the plating ground layer 71. In addition, if it is made 60 degrees or less at 45 degrees or more, it is possible removal of plating ground layer 71a and the adhesion film 78 and to perform ** truck-ization at 1 time of an ion milling process further, and a manufacturing process can be simplified.

[0150] However, you may perform the removal process of plating ground layer 71a, the removal process of the adhesion film 78, and a ** truck-ized process by the ion milling which has a respectively different milling angle.

[0151] In addition, in this invention, as for the height size H1 of the aforementioned main pole layer 24, it is desirable that it is about 0.5 micrometers or less in 0.25 micrometers or more, as for the width of recording track Tw of the aforementioned main pole layer 24, it is desirable that it is 0.7 micrometers or less, and it is 0.5 micrometers or less more preferably.

[0152] Moreover, in this invention, the aforementioned plating ground layer 71 for plating ground layer [for yoke layer 35 formation] 72 and main pole layer 24 formation may be a magnetic plating material, and may be nonmagnetic plating material. In addition, since it extends a little to the circumference under the aforementioned main pole layer 24 and the aforementioned plating ground layer 71 may be left behind when nonmagnetic, for example, metallic materials, such as Cu, is used for the aforementioned plating ground layer 71 for the main pole layer 24 aforementioned formation, compared with the case where a magnetic plating material is used for the aforementioned plating ground layer 71, etching control can be made easy.

[0153] What is necessary is to be formed in the resist layer 75 at the time of the process shown in drawing 20 , to extract, to extend further 75d of back end sides of pattern 75a in the height direction (the direction of illustration Y) (field of sign 75c), and just to arrange the 75d of the aforementioned back end sides with back end side 35b of the aforementioned yoke layer 35, in manufacturing the vertical-magnetic-recording head shown in drawing 2 .

[0154] Moreover, what is necessary is to have been formed in the resist layer 75 at the time of the process of drawing 23 and drawing 24 , to extract, and just to carry out plating growth only of the main pole layer 24 into pattern 75a, in manufacturing the vertical-magnetic-recording head shown in drawing 3 .

[0155] In addition, it is possible for the resist layer 75 shown in drawing 22 by this invention to acquire the effect of this invention, even if the inside width method of the direction of the width of recording track in the aforementioned opposed face H1a (the direction of illustration X) does not need to be formed so that it may apply to the upper surface and may spread from an inferior surface of tongue, and front end side 24a of the aforementioned main pole layer 24 is formed in configurations, such as a square and a rectangle, as usual.

[0156] Moreover, with the operation gestalt shown in drawing 1 and drawing 2 , although read station HR is formed, this does not need to be formed.

[0157]

[Effect of the Invention] By this invention, it forms as mentioned above in respect of the inclined plane which inclines in the height direction, applying the front end side of the yoke layer formed on an insulating layer to the upper surface from the undersurface, or a curve.

[0158] For this reason, since the thickness of the aforementioned resist layer can be mostly formed in homogeneity when forming the main pole layer formed on the aforementioned yoke layer from on the insulating layer located ahead rather than the aforementioned yoke layer, applying using a resist layer, when it extracts for the aforementioned main pole layer formation in the aforementioned resist layer and a pattern forms in exposure development, resist **** like before does not occur in the aforementioned omission pattern.

[0159] Therefore, in this invention, a plating ground layer can be exposed on the aforementioned whole surface in an omission pattern, and plating growth of the main pole layer of a predetermined configuration can be carried out appropriately on the aforementioned plating ground layer.

[0160] Moreover, it is possible to be able to raise pattern precision, since the thickness of the resist layer for forming the aforementioned main pole layer can be mostly formed in homogeneity, if the front end side of the aforementioned yoke layer is formed in respect of the gently-sloping inclined plane or the curve as mentioned above, therefore to form the aforementioned main pole layer with a sufficient pattern precision, and the front end side of the aforementioned main pole layer can be formed in the predetermined width of recording track Tw and a predetermined predetermined configuration.

[0161] Moreover, in this invention, by the front end side of the aforementioned yoke layer being a gently-sloping inclined plane or a curve side, magnetic flux is smoothly led to the aforementioned main pole layer from the aforementioned yoke layer, and the passage efficiency of magnetic flux can be raised. That is, in this invention, the magnetic flux which leaks from the front end side of the aforementioned yoke layer can be decreased, magnetic flux can be centralized suitable for the aforementioned main pole layer, and the vertical-magnetic-recording head which can respond can be manufactured suitable for the future formation of high record dense.

[Translation done.]

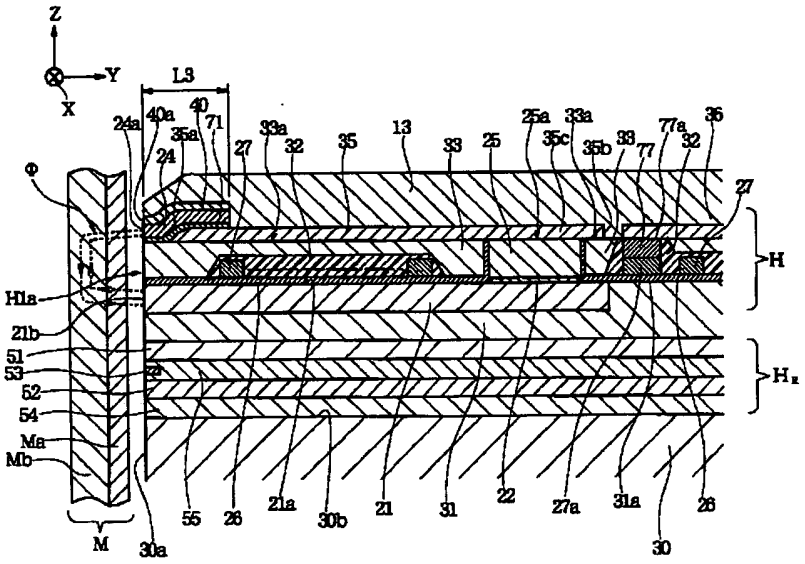
* NOTICES *

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DRAWINGS

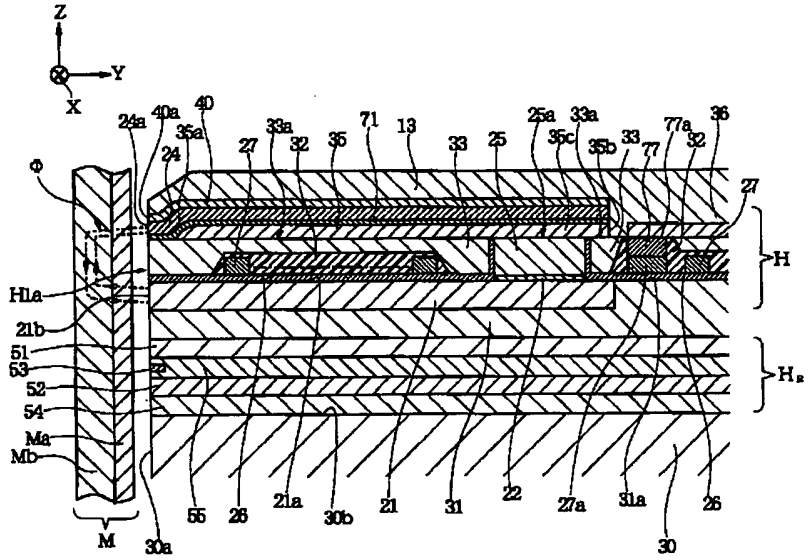
[Drawing 1]

図1



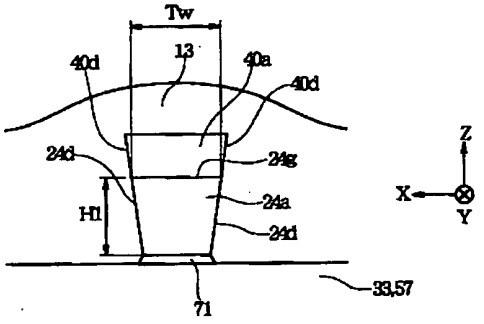
[Drawing 2]

図2



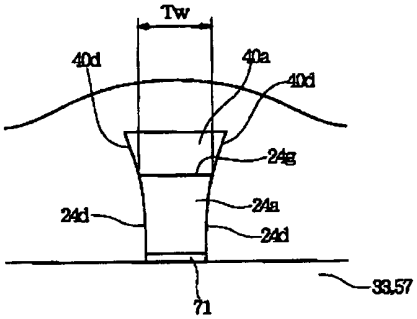
[Drawing 4]

図4



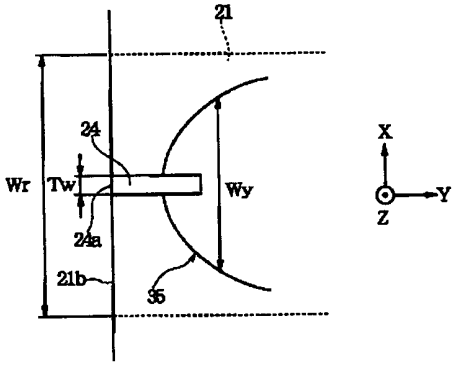
[Drawing 5]

図5



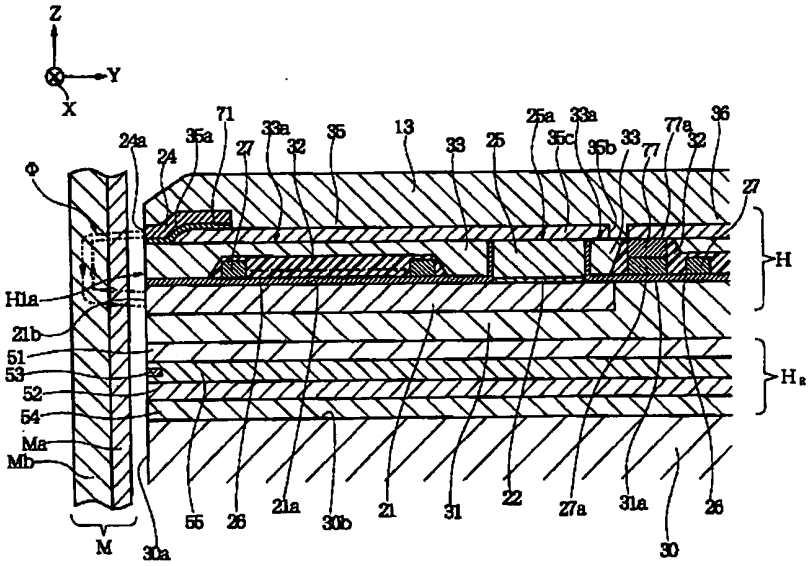
[Drawing 7]

図7



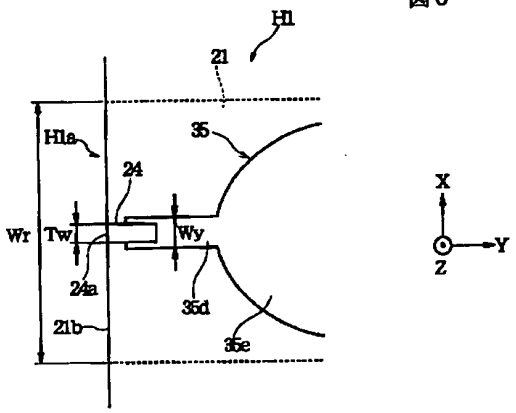
[Drawing 3]

図3



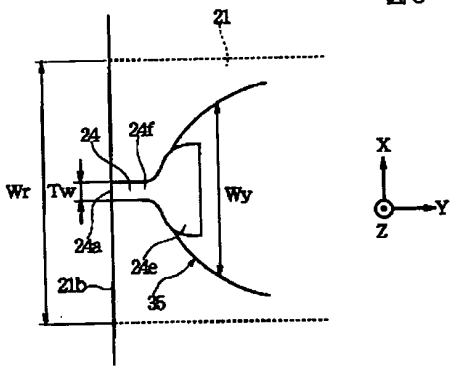
[Drawing 6]

図 6



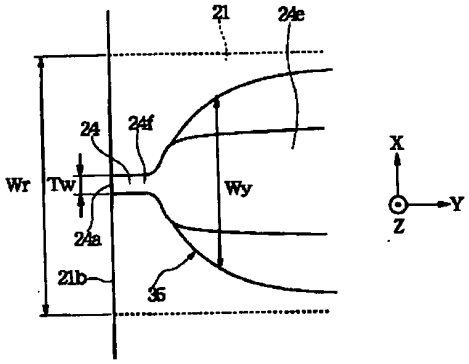
[Drawing 8]

図 8



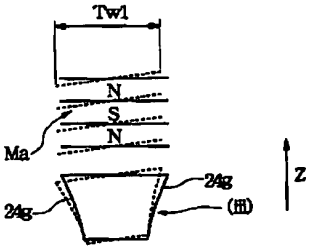
[Drawing 9]

図 9



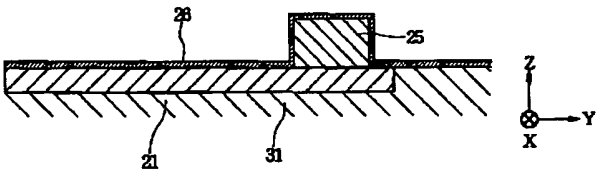
[Drawing 10]

図 10



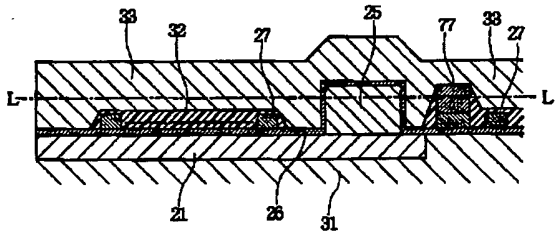
[Drawing 11]

図 11



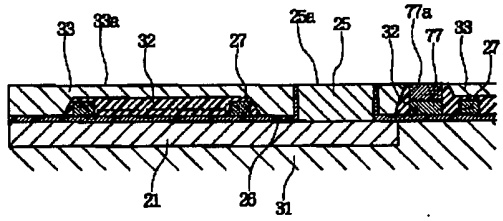
[Drawing 12]

図 12



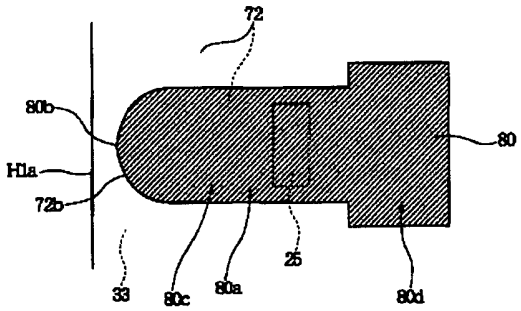
[Drawing 13]

図 13



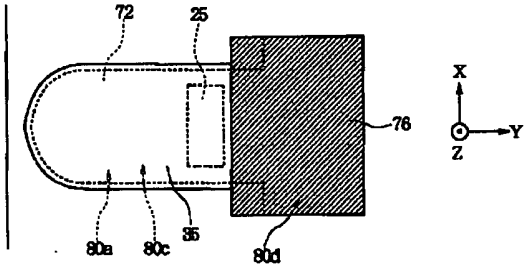
[Drawing 14]

図 14



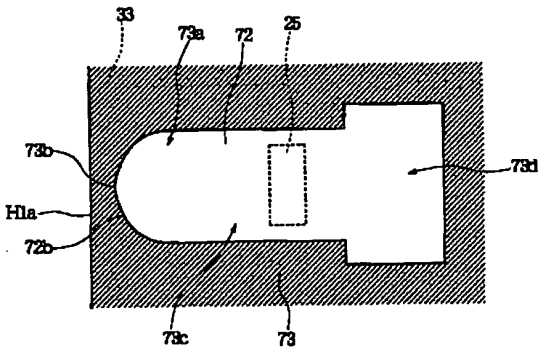
[Drawing 15]

図 15



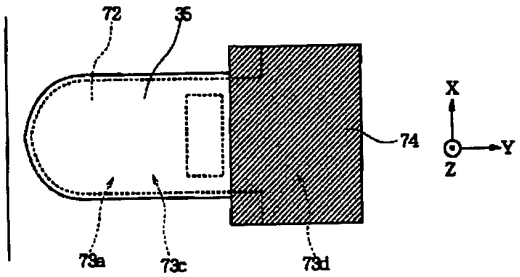
[Drawing 16]

図 16



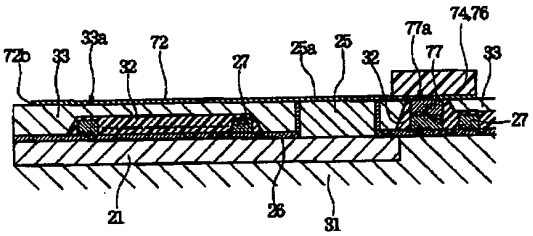
[Drawing 17]

図 17



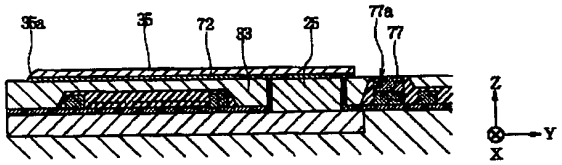
[Drawing 18]

図 18



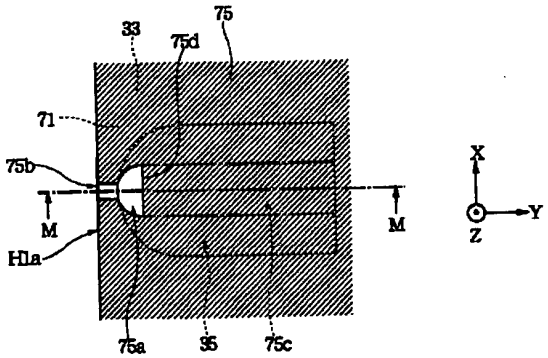
[Drawing 19]

図 19



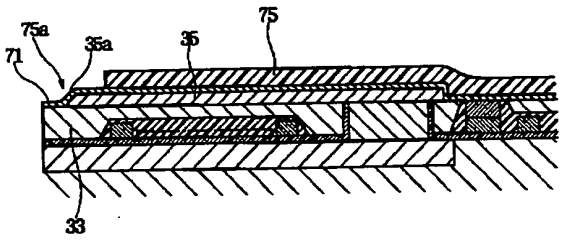
[Drawing 20]

図 20



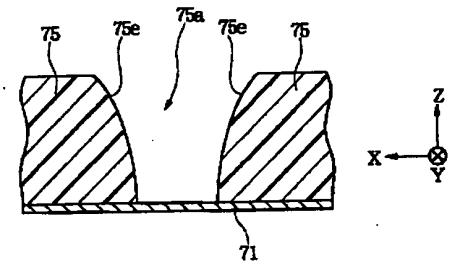
[Drawing 21]

図 21



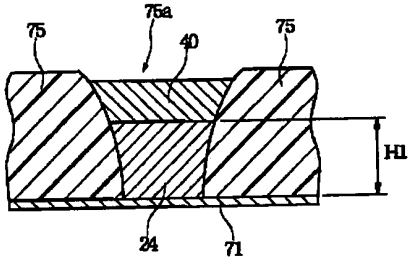
[Drawing 22]

図 22



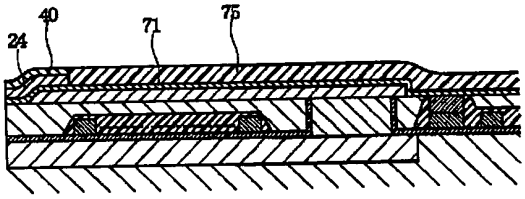
[Drawing 23]

図 23



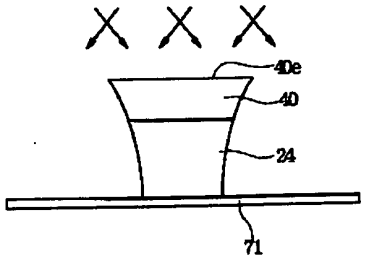
[Drawing 24]

図 24



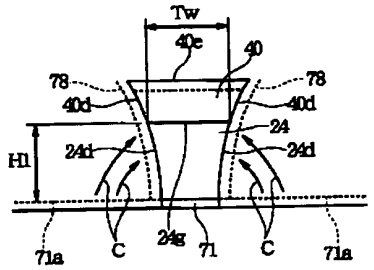
[Drawing 25]

図 25



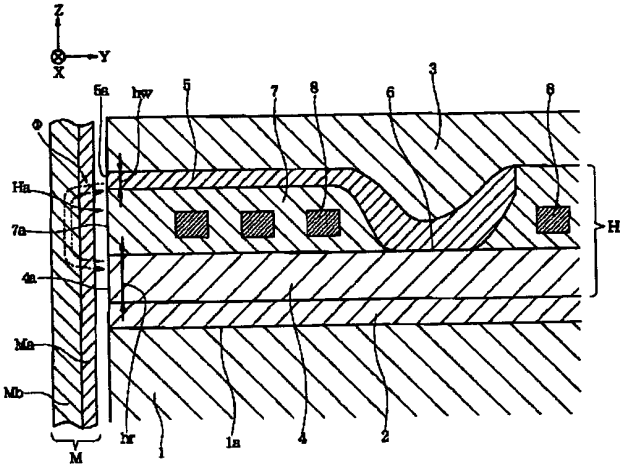
[Drawing 26]

図 26



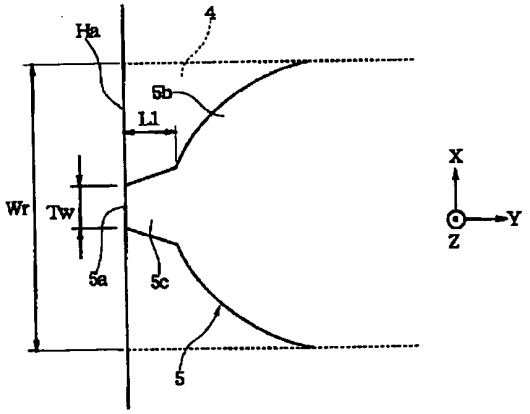
[Drawing 27]

図 27



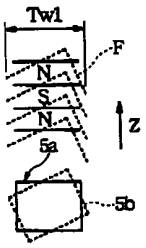
[Drawing 28]

図 28



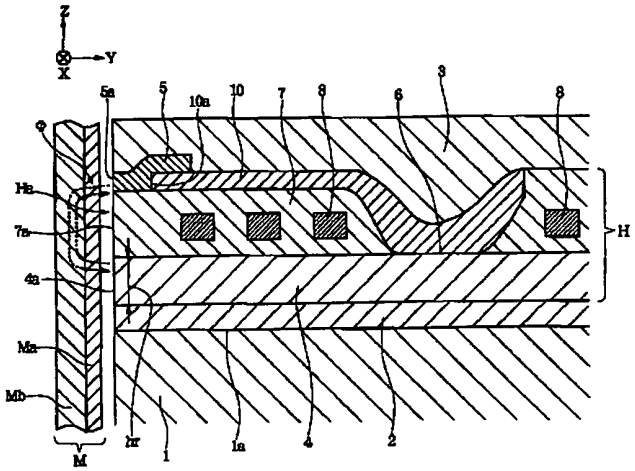
[Drawing 33]

図 33



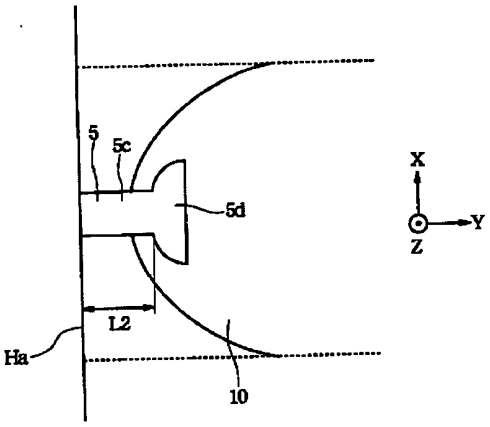
[Drawing 29]

図 29



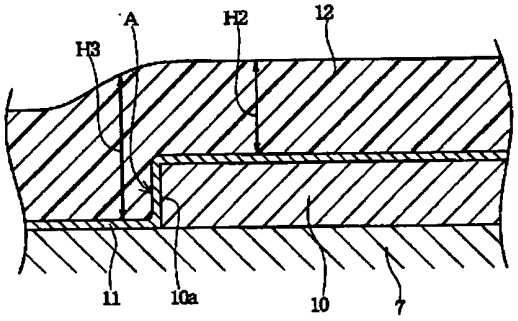
[Drawing 30]

図 30



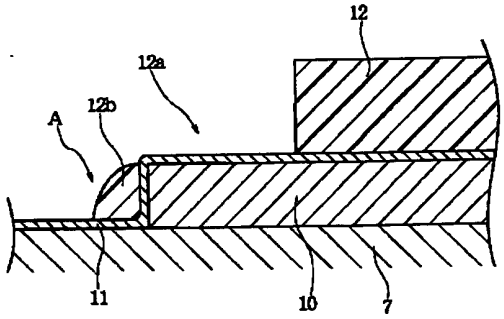
[Drawing 31]

図 31



[Drawing 32]

図 32



[Translation done.]

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Ｇ１１Ｂ　5/31		Ｇ１１Ｂ　5/31	Ｃ	5D033
			Ｄ	

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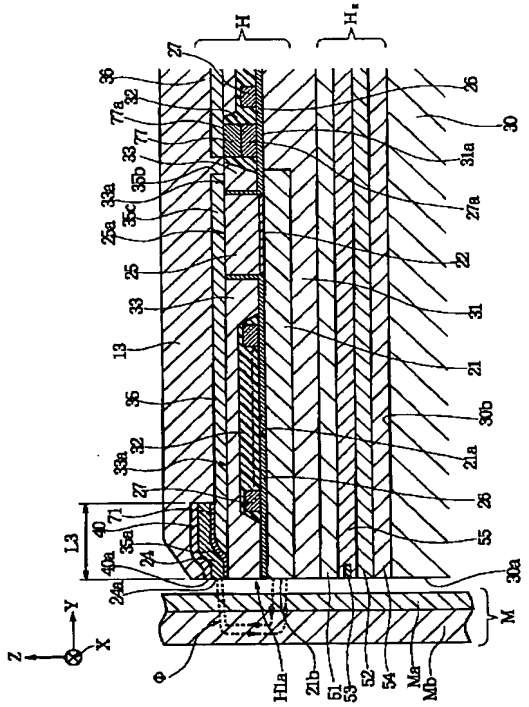
弁理士　野▲崎▼　照夫

Ｆターム(参考)　5D033 AA01 BA07 BA12 CA02 DA04 DA08 DA31

(54)【発明の名称】垂直磁気記録ヘッドおよびその製造方法

(57)【要約】
【課題】　従来の垂直磁気記録方式の垂直磁気記録ヘッドでは、ヨーク層上に主磁極層を適切にメッキ成長させることができず、また前記ヨーク層の前端面から漏れ磁束が大きいために、前記ヨーク層から主磁極層への磁束の通過効率が悪く、高記録密度化に対応可能な垂直磁気記録ヘッドを製造できなかった。
【解決手段】　ヨーク層３５の前端面３５ａを下面から上面にかけてハイト方向に傾く傾斜面あるいは湾曲面で形成する。これにより主磁極層２４を所定形状で適切にメッキ形成できると共に、前記ヨーク層３５から主磁極層２４への磁束の通過効率を向上させ、高記録密度化に対応可能な垂直磁気記録ヘッドを製造することが可能になる。

図1



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【特許請求の範囲】

【請求項１】　記録媒体との対向面に、補助磁極層と主磁極層とが間隔を開けて位置し、前記対向面よりもハイト方向後方に前記補助磁極層と前記主磁極層とに記録磁界を与えるコイル層が設けられ、前記主磁極層に集中する垂直磁界によって、前記記録媒体に磁気データを記録する垂直磁気記録ヘッドにおいて、

前記対向面よりもハイト方向後方では前記補助磁極層から立ち上がる接続層が設けられ、前記接続層の周囲に前記コイル層が巻回形成されており、

前記コイル層上は絶縁層によって覆われ、前記絶縁層上には、前記対向面側の前端面がハイト方向後方に位置し、しかも前記前端面が下面から上面にかけてハイト方向に傾く傾斜面あるいは湾曲面とされたヨーク層が形成され、前記ヨーク層の基端部は前記接続層と磁気的に接続されており、

前記対向面での絶縁層上から前記ヨーク層上にかけて主磁極層が形成されていることを特徴とする垂直磁気記録ヘッド。

【請求項２】　前記絶縁層の上面と前記接続層の上面は同一面とされた平坦化面となっている請求項１記載の垂直磁気記録ヘッド。

【請求項３】　前記対向面に現れている前記主磁極層の前端面は、下面から上面に向けてトラック幅方向の幅寸法が広がる形状で形成されている請求項１または２に記載の垂直磁気記録ヘッド。

【請求項４】　前記前端面の両側端面は、傾斜面あるいは湾曲面で形成されている請求項３記載の垂直磁気記録ヘッド。

【請求項５】　前記主磁極層の飽和磁束密度が、前記ヨーク層の飽和磁束密度よりも高い請求項１ないし４のいずれかに記載の垂直磁気記録ヘッド。

【請求項６】　前記ヨーク層と主磁極層とが重なる位置での前記ヨーク層の前記対向面と平行な方向からの断面積は、前記主磁極層の前記対向面と平行な方向からの断面積よりも大きい請求項１ないし５のいずれかに記載の垂直磁気記録ヘッド。

【請求項７】　以下の工程を有することを特徴とする垂直磁気記録ヘッドの製造方法。

（ａ）磁性材料で補助磁極層を形成する工程と、（ｂ）前記補助磁極層上であって、記録媒体との対向面よりもハイト方向後方に接続層を形成し、次に前記対向面と接続層間に、前記補助磁極層上に絶縁下地層を介してコイル層を形成した後、前記コイル層上を絶縁層で埋める工程と、（ｃ）前記絶縁層の表面を削り、前記絶縁層上面と前記接続層上面を同一面とする工程と、（ｄ）前記絶縁層上面及び接続層上面に、前端面が前記対向面よりもハイト方向後方に位置し且つ前記接続層上にまで延びるヨーク層形状のメッキ下地層を形成する工程と、（ｅ）前記メッキ下地層上に磁性材料でヨーク層をメッキ形成し、このとき前記ヨーク層の前端面を下面から上面にかけてハイト方向に傾く傾斜面あるいは湾曲面にする工程と、（ｆ）前記絶縁層上及びヨーク層上にメッキ下地層を形成し、前記メッキ下地層上にレジスト層を形成した後、前記レジスト層に前記対向面での絶縁層上から前記ヨーク層上にまで延びる抜きパターンを形成する工程と、（ｇ）前記抜きパターン内に露出した前記メッキ下地層上に磁性材料で主磁極層をメッキ形成した後、前記レジスト層を除去する工程。

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【請求項８】　前記（ｄ）工程において、メッキ下地層を以下の工程で形成する請求項７記載の垂直磁気記録ヘッドの製造方法。

（ｈ）前記絶縁層上面及び接続層上面にメッキ下地層を形成し、さらに前記メッキ下地層上にレジスト層を形成する工程と、（ｉ）前端面が前記対向面よりもハイト方向後方に位置し且つ前記接続層上にまで延びるヨーク層形状のレジスト層を残し、他のレジスト層を除去する工程と、（ｊ）レジスト層に覆われていないメッキ下地層を除去した後、前記レジスト層を除去する工程。

【請求項９】　前記（ｄ）工程において、メッキ下地層を以下の工程で形成する請求項７記載の垂直磁気記録ヘッドの製造方法。

（ｋ）前記絶縁層上面及び接続層上面にレジスト層を形成し、さらに前記レジスト層に前端面が前記対向面よりもハイト方向後方に位置し且つ前記接続層上にまで延びるヨーク層形状の抜きパターンを前記レジスト層に形成する工程と、（ｌ）前記抜きパターン内にメッキ下地層をスパッタ成膜した後、前記レジスト層を除去する工程。

【請求項１０】　前記（ｆ）工程において、少なくとも前記対向面でのトラック幅方向の内幅寸法が、下面から上面にかけて広がる抜きパターンを前記レジスト層に形成する請求項７ないし９のいずれかに記載の垂直磁気記録ヘッドの製造方法。

【請求項１１】　前記（ｇ）工程で、さらに前記主磁極層の下以外に形成された前記メッキ下地層を除去する請求項７ないし１１のいずれかに記載の垂直磁気記録ヘッドの製造方法。

【発明の詳細な説明】

【０００１】

【発明の属する技術分野】本発明は、ハード膜を有するディスクなどの記録媒体に対して垂直磁界を与えて記録を行う垂直磁気記録ヘッドに係り、特に主磁極層を絶縁層上からヨーク層上にかけて適切にメッキ形成でき、しかも前記ヨーク層から主磁極層への磁束の通過効率を向上させることが可能な垂直磁気記録ヘッド及びその製造方法に関する。

【０００２】

【従来の技術】ディスクなどの記録媒体に磁気データを高密度で記録する装置として垂直磁気記録方式がある。

図２７は前記垂直磁気記録方式の装置に使用される垂直磁気記録ヘッドの一般的な構造を示す断面図である。

【０００３】図２７に示すように、垂直磁気記録方式の垂直磁気記録ヘッドＨは、記録媒体上を浮上して移動しまたは摺動するスライダ１の側端面に設けられるものであり、例えばスライダ１の側端面１ａにおいて、前記垂直磁気記録ヘッドＨは、非磁性膜２と、非磁性の被覆膜３との間に配置される。

【０００４】前記垂直磁気記録ヘッドＨは、強磁性材料で形成された補助磁極層４と、前記補助磁極層４の上に間隔を開けて形成された同じく強磁性材料で形成された主磁極層５とを有しており、前記補助磁極層４の端面４ａと前記主磁極層５の端面５ａとが、記録媒体Ｍとの対向面Ｈａに現れている。前記対向面Ｈａよりも奥側において、前記補助磁極層４と前記主磁極層５は、磁気接続部６において磁気的に接続されている。

【０００５】前記補助磁極層４と前記主磁極層５との間にはAl_2O_3、SiO_2などの無機材料による非磁性絶縁層７が位置しており、前記対向面Ｈａでは、この非磁性絶縁層７の端面７ａが、前記補助磁極層４の端面４ａと前記主磁極層５の端面５ａとの間に現れている。

【０００６】そして、前記非磁性絶縁層７内には、Ｃｕなどの導電性材料で形成されたコイル層８が埋設されている。

【０００７】図２７に示すように、主磁極層５の端面５ａの厚みｈｗは、補助磁極層４の端面４ａの厚みｈｒよりも小さくなっている。また図２８の平面図に示すように、前記主磁極層５のトラック幅方向（図示Ｘ方向）の端面５ａの幅寸法はトラック幅Ｔｗであり、この幅寸法は、前記補助磁極層４のトラック幅方向の端面４ａの幅寸法Ｗｒよりも十分に小さくなっている。

【０００８】前記垂直磁気記録ヘッドＨにより磁気記録が行われる記録媒体Ｍは、垂直磁気記録ヘッドＨに対してＺ方向へ移動するものであり、その表面にハード膜Ｍａが内方にソフト膜Ｍｂが設けられている。

【０００９】前記コイル層８に通電されることにより補助磁極層４と主磁極層５とに記録磁界が誘導されると、補助磁極層４の端面４ａと、主磁極層５の端面５ａとの間での漏れ記録磁界が、記録媒体Ｍのハード膜Ｍａを垂直に通過し、ソフト膜Ｍｂを通る。ここで、前記のように主磁極層５の端面５ａの面積が、補助磁極層４の端面４ａでの面積よりも十分に小さくなっているため、主磁極層５の端面５ａの対向部分で磁束φが集中し、端面５ａが対向する部分での前記ハード膜Ｍａに対し、前記磁束φにより磁気データが記録される。

【００１０】ところで図２８の平面図に示すように、前記主磁極層５は、前記対向面Ｈａからハイト方向後方に長さ寸法がＬ１で形成された幅細の前方領域５ｃと、前記前方領域５ｃの基端からハイト方向後方にかけてトラック幅方向（図示Ｘ方向）の幅寸法が漸次的に広がるヨーク部５ｂとで構成されている。

【００１１】前記前方領域５ｃの長さ寸法Ｌ１はできる限り短く形成することが、前記前方領域５ｃでの磁気飽和を緩和し、前記ヨーク部５ｃから流れる磁束を前記主磁極層５の前端面５ａから集中して発生させることができて好ましい。

【００１２】しかし前記長さ寸法Ｌ１を短くしすぎると、前方領域５ｃの微小なパターンを正確に形成することは困難で、前記前端面５ａのトラック幅Ｔｗが所定値より広がって形成されたり、あるいは図２８に示すように、ハイト方向（図示Ｙ方向）に向かうにしたがってトラック幅方向（図示Ｘ方向）の幅寸法が広がって形成されてしまい、トラック幅Ｔｗ及び前記前方領域５ｃの形状の制御が非常に難しかった。

【００１３】このような形状変化の問題は、前記主磁極層５の前方領域５ｃとヨーク部５ｂとが一体に形成された単一層によるところが大きく、このためヨーク部５ｂを前記前方領域５ｃとは別に形成する構造が考えられている。

【００１４】図２９は、図２７に示す従来の垂直磁気記録ヘッドを改良した縦断面図であり、図２９に示すように非磁性絶縁層７上にはヨーク層１０が形成されている。前記ヨーク層１０の前端面１０ａは、前記対向面Ｈａからハイト方向（図示Ｙ方向）後方に位置し、しかも非磁性絶縁層７から垂直に立ち上がって形成されている。また図２９に示すように前記対向面Ｈａでの非磁性絶縁層７上から前記ヨーク層１０上にかけて主磁極層５が形成されている。図２９に示す垂直磁気記録ヘッドの平面図は例えば図３０のような平面形状であり、図３０に示すように、前記ヨーク層１０はハイト方向（図示Ｙ方向）に向かうにしたがってトラック幅方向（図示Ｘ方向）の幅寸法が漸次的に広がる形状であり、前記主磁極層５は、前端面５ａがトラック幅Ｔｗで形成された幅細形状の前方領域５ｃとこの前方領域５ｃの基端からトラック幅方向への幅寸法が広がる後方領域５ｄとで構成されている。

【００１５】図２９、３０のように、前記ヨーク層１０上に主磁極層５を重ね合わせる構造であると、前記主磁極層５の前方領域５ｃのハイト方向（図示Ｙ方向）への長さ寸法Ｌ２を従来より長く形成しても、前記ヨーク層１０をできる限り対向面Ｈａ側に寄せて形成することで、前記前方領域５ｃが磁気飽和に達することなく、前記ヨーク層１０からの磁束を適切に前記主磁極層５の前方領域５ｃに導くことができる。

【００１６】このように図３０に示す構造であると前記主磁極層５の前方領域５ｃをハイト方向へ長く形成できるから、パターン精度が向上し前記前方領域５ｃを所定のトラック幅Ｔｗ及び所定の形状で形成できると考えられた。

【００１７】

【発明が解決しようとする課題】しかしながら図２９に示す垂直磁気記録ヘッドでは前記ヨーク層１０の前端面１０ａが非磁性絶縁層７の上面から垂直に立ちあがって形成されているために、前記非磁性絶縁層７と前記前端面１０ａ間には大きな段差が形成される。このため前記主磁極層５の形成工程時に、以下のような問題が発生した。図３１及び図３２は前記主磁極層５を形成する際の製造方法を示す一工程図である。

【００１８】図３１に示すように、前記非磁性絶縁層７上にヨーク層１０を形成し、さらに前記非磁性絶縁層７上から前記ヨーク層１０上にかけてメッキ下地層１１を形成する。このメッキ下地層１１は次工程で主磁極層５をメッキ成長させるための下地である。さらに前記メッキ下地層１１上にレジスト層１２を形成する。

【００１９】図３１に示すように、前記ヨーク層１０の前端面１０ａは非磁性絶縁層７上から垂直に立ちあがって形成されているために前記前端面１０ａと非磁性絶縁層７間には大きな段差Ａが生じる。

【００２０】このため前記非磁性絶縁層７上からヨーク層１０上にかけて塗布されるレジスト層１２には、前記ヨーク層１０上に塗布されたレジスト層１２の膜厚Ｈ２と前記非磁性絶縁層７上に塗布されたレジスト層１２の膜厚Ｈ３とに大きさ差が生じる。

【００２１】次の図３２に示す工程では、前記レジスト層１２に主磁極層５形成のための抜きパターン１２ａを露光現像で形成するが、このとき、ヨーク層１０上のレジスト層１２に対し、前記段差Ａの部分で前記レジスト層１２の膜厚が急激に厚くなるため、この段差Ａの部分に塗布されたレジスト層１２の下面にまで適切に露光がなされず、前記段差Ａの部分に露光現像されないレジスト層１２ｂが残りやすい。

【００２２】そして次に前記抜きパターン１２ａ内に露出したメッキ下地層１１上から主磁極層５をメッキ成長させようとしても、前記抜きパターン１２ａ内にレジスト層１２ｂが残っていると、その部分ではメッキ下地層１１が前記レジスト層１２ｂに覆われているのでメッキ成長が適切になされず、前記レジスト層１２ｂ上には極端に薄い膜厚の主磁極層５が形成されたり、あるいはこの部分に全く主磁極層５が形成されないなど、不良品が形成されやすい。

【００２３】またヨーク層１０と非磁性絶縁層７間に大きな段差Ａがあり、レジスト層１２の膜厚に大きな差があると、前記抜きパターン１２ａのパターン精度は低下するため、特に前記主磁極層５の前方領域５ｃを所定のトラック幅Ｔｗ及び所定の形状で形成できず、狭トラック化に対応可能な垂直磁気記録ヘッドを製造することができない。

【００２４】また前記ヨーク層１０の前端面１０ａが非磁性絶縁層７上から垂直に立ちあがり、前記主磁極層５と重なる位置において前記ヨーク層１０が略矩形状で形成されていると、前記ヨーク層１０の前端面１０ａから磁束が洩れやすくなり、すなわち前記磁束が前記ヨーク層１０から主磁極層５に適切に導かれず、磁束の通過効率が低下して、記録密度の低下を招く。

【００２５】そこで本発明は上記従来の課題を解決するものであり、前記ヨーク層の前端面をなだらかな傾斜面や湾曲面とすることで、前記主磁極層を絶縁層上から前記ヨーク層上にかけて適切にメッキ形成することができ、また前記ヨーク層から主磁極層への磁束の通過効率を向上させることが可能な垂直磁気記録ヘッド及びその製造方法を提供することを目的としている。

【００２６】

【課題を解決するための手段】本発明は、記録媒体との対向面に、補助磁極層と主磁極層とが間隔を開けて位置し、前記対向面よりもハイト方向後方に前記補助磁極層と前記主磁極層とに記録磁界を与えるコイル層が設けられ、前記主磁極層に集中する垂直磁界によって、前記記録媒体に磁気データを記録する垂直磁気記録ヘッドにおいて、前記対向面よりもハイト方向後方では前記補助磁極層から立ち上がる接続層が設けられ、前記接続層の周囲に前記コイル層が巻回形成されており、前記コイル層上は絶縁層によって覆われ、前記絶縁層上には、前記対向面側の前端面がハイト方向後方に位置し、しかも前記前端面が下面から上面にかけてハイト方向に傾く傾斜面あるいは湾曲面とされたヨーク層が形成され、前記ヨーク層の基端部は前記接続層と磁気的に接続されており、前記対向面での絶縁層上から前記ヨーク層上にかけて主磁極層が形成されていることを特徴とするものである。

【００２７】本発明では、前記ヨーク層の前端面には、下面から上面にかけてハイト方向に傾く傾斜面あるいは湾曲面が形成されている。

【００２８】このように本発明では従来と異なり、前記ヨーク層の前端面が垂直面として立ち上がる形状ではなく、前記前端面がなだらかな傾斜面あるいは湾曲面でハイト方向に向けて立ち上がる形状であると、前記ヨーク層の前方に位置する絶縁層上からヨーク層上にかけて主磁極層を形成するときに使用されるレジスト層をほぼ均一な膜厚で形成でき、したがって前記レジスト層に形成される抜きパターン内のレジスト層を上面から下面にかけて適切に露光現像して除去できる。よって本発明では従来のように前記抜きパターン内にレジスト溜りが発生せず、前記抜きパターン内一面に主磁極層を形成するためのメッキ下地層を露出させることができるので、前記抜きパターン内に前記主磁極層を所定形状で適切にメッキ形成することが可能である。

【００２９】また本発明では、上記のように、前記絶縁層上から前記ヨーク層の前端面が徐々に膜厚が大きくなるようになだらかに立ち上がり、主磁極層形成の際に使用される前記絶縁層上からヨーク層上にかけてのレジスト層の膜厚をほぼ一定にできることから、主磁極層をパ

ターン精度良く形成することが可能であり、前記主磁極層の前端面を所定のトラック幅Ｔｗ及び所定の形状で高精度に形成しやすい。

【００３０】また本発明では、前記ヨーク層の前端面が、ハイト方向にかけて徐々に膜厚が厚くなるようになだらかな傾斜面あるいは湾曲面となっていると、前記ヨーク層からの磁束は、主磁極層にスムーズに導かれ、前記前端面からの磁束の漏れを従来よりも抑制できる。すなわち本発明では前記ヨーク層から主磁極層への磁束の通過効率を向上させることができ、前記主磁極層に磁束を集中させることができるので、高記録密度化に優れた垂直磁気記録ヘッドを製造することが可能である。

【００３１】また本発明では、前記絶縁層の上面と前記接続層の上面は同一面とされた平坦化面となっていることが好ましい。これによりヨーク層及び主磁極層をパターン精度良く形成することができる。

【００３２】また本発明では、前記対向面に現れている前記主磁極層の前端面は、下面から上面に向けてトラック幅方向の幅寸法が広がる形状で形成されていることが好ましく、かかる場合、前記前端面の両側端面は、傾斜面あるいは湾曲面で形成されていることが好ましい。

【００３３】また本発明では、前記主磁極層の飽和磁束密度が、前記ヨーク層の飽和磁束密度よりも高いことが好ましい。本発明では前記主磁極層とヨーク層とを別々に形成することができる。このため前記主磁極層にヨーク層よりも飽和磁束密度が高い磁性材料を選択することが可能になり、これにより前記主磁極層に磁束を集約させることができ、高記録密度化に適切に対応可能な垂直磁気記録ヘッドを製造することが可能である。

【００３４】また本発明では、前記ヨーク層と主磁極層とが重なる位置での前記ヨーク層の前記対向面と平行な方向からの断面積は、前記主磁極層の前記対向面と平行な方向からの断面積よりも大きいことが好ましい。これにより前記ヨーク層から主磁極層への磁束の通過効率を向上させることが可能である。

【００３５】また本発明における垂直磁気記録ヘッドの製造方法は、以下の工程を有することを特徴とするものである。

（ａ）磁性材料で補助磁極層を形成する工程と、（ｂ）前記補助磁極層上であって、記録媒体との対向面よりもハイト方向後方に接続層を形成し、次に前記対向面と接続層間に、前記補助磁極層上に絶縁下地層を介してコイル層を形成した後、前記コイル層上を絶縁層で埋める工程と、（ｃ）前記絶縁層の表面を削り、前記絶縁層上面と前記接続層上面を同一面とする工程と、（ｄ）前記絶縁層上面及び接続層上面に、前端面が前記対向面よりもハイト方向後方に位置し且つ前記接続層上にまで延びるヨーク層形状のメッキ下地層を形成する工程と、（ｅ）前記メッキ下地層上に磁性材料でヨーク層をメッキ形成し、このとき前記ヨーク層の前端面を下面から上面にかけてハイト方向に傾く傾斜面あるいは湾曲面にする工程と、（ｆ）前記絶縁層上及びヨーク層上にメッキ下地層を形成し、前記メッキ下地層上にレジスト層を形成した後、前記レジスト層に前記対向面での絶縁層上から前記ヨーク層上にまで延びる抜きパターンを形成する工程と、（ｇ）前記抜きパターン内に露出した前記メッキ下地層上に磁性材料で主磁極層をメッキ形成した後、前記レジスト層を除去する工程。

【００３６】本発明では、前記（ｄ）工程でヨーク層形成のためのメッキ下地層を絶縁層上に形成し、前記（ｅ）工程では、前記メッキ下地層上にヨーク層をメッキ成長させている。前記（ｄ）工程では、前記メッキ下地層の周囲は、レジスト層などによって囲まれておらず、平坦化された絶縁層上にはメッキ下地層のみが形成されており、このようにレジスト層などによる囲みの無いメッキ下地層上からメッキ成長するヨーク層の前端面は丸みを帯びながら成長していき、前記ヨーク層の前端面を下面から上面にかけてハイト方向に傾く傾斜面あるいは湾曲面で形成することができる。

【００３７】そして本発明では前記ヨーク層の前端面がなだらかな傾斜面あるいは湾曲面になっているため、上記（ｆ）工程で、前記ヨーク層の前方の絶縁層上からヨーク層上にかけて形成されるレジスト層の膜厚をほぼ均一にすることができる。

【００３８】このため前記レジスト層に主磁極層の抜きパターンを露光現像で形成するとき、前記抜きパターン内のレジスト層を下面から上面の全域にかけて適切に露光現像して除去でき、前記抜きパターン内には従来のようにレジスト溜りが発生しない。

【００３９】よって前記抜きパターン内には、適切に主磁極層形成のためのメッキ下地層が露出しており、したがって前記（ｇ）工程で前記メッキ下地層上に主磁極層を所定形状で適切にメッキ成長させることが可能である。

【００４０】また本発明では、前記（ｄ）工程において、メッキ下地層を以下の工程で形成することが好ましい。

（ｈ）前記絶縁層上面及び接続層上面にメッキ下地層を形成し、さらに前記メッキ下地層上にレジスト層を形成する工程と、（ｉ）前端面が前記対向面よりもハイト方向後方に位置し且つ前記接続層上にまで延びるヨーク層形状のレジスト層を残し、他のレジスト層を除去する工程と、（ｊ）レジスト層に覆われていないメッキ下地層を除去した後、前記レジスト層を除去する工程。

【００４１】あるいは本発明では、前記（ｄ）工程において、メッキ下地層を以下の工程で形成してもよい。

（ｋ）前記絶縁層上面及び接続層上面にレジスト層を形成し、さらに前記レジスト層に前端面が前記対向面よりもハイト方向後方に位置し且つ前記接続層上にまで延びるヨーク層形状の抜きパターンを前記レジスト層に形成

する工程と、（ｌ）前記抜きパターン内にメッキ下地層をスパッタ成膜した後、前記レジスト層を除去する工程。

【００４２】上記のメッキ下地層の形成方法によれば、前記メッキ下地層の周囲はレジスト層などで囲まれておらず、前記メッキ下地層の周囲には前記絶縁層のみが広がった状態になっている。従って前記メッキ下地層の上にヨーク層をメッキ成長させると、前記ヨーク層の周囲は丸みを帯びながら成長していき、前記ヨーク層の前端面を下面から上面にかけてハイト方向に傾く傾斜面あるいは湾曲面として形成できる。

【００４３】また本発明では、前記（ｆ）工程において、少なくとも前記対向面でのトラック幅方向の内幅寸法が、下面から上面にかけて広がる抜きパターンを前記レジスト層に形成することが好ましい。

【００４４】これにより前記主磁極層の前端面を下面から上面にかけて幅寸法が徐々に広がる形状に形成できる。

【００４５】また本発明では、前記（ｇ）工程で、さらに前記主磁極層の下以外に形成された前記メッキ下地層を除去することが好ましい。

【００４６】

【発明の実施の形態】図１は本発明の第１実施形態の垂直磁気記録ヘッドを備えた磁気ヘッドの構造を示す縦断面図である。

【００４７】図１に示す垂直磁気記録ヘッドＨは記録媒体Ｍに垂直磁界を与え、記録媒体Ｍのハード膜Ｍａを垂直方向に磁化させるものである。

【００４８】前記記録媒体Ｍはディスク状であり、その表面に残留磁化の高いハード膜Ｍａが、内方に磁気透過率の高いソフト膜Ｍｂを有しており、ディスクの中心が回転軸中心となって回転させられる。

【００４９】前記垂直磁気記録ヘッドＨのスライダ３０はAl_2O_3・ＴｉＣなどのセラミック材料で形成されており、スライダ３０の対向面３０ａが前記記録媒体Ｍに対向し、記録媒体Ｍが回転すると、表面の空気流によりスライダ３０が記録媒体Ｍの表面から浮上し、またはスライダ３０が記録媒体Ｍに摺動する。図１においてスライダ３０に対する記録媒体Ｍの移動方向は図示Ｚ方向である。前記垂直磁気ヘッドＨはスライダ３０のトレーリング側端面に設けられている。

【００５０】前記スライダ３０の側端面３０ｂには、Al_2O_3またはSiO_2などの無機材料による非磁性絶縁層５４が形成されて、この非磁性絶縁層の上に読取り部H_Rが形成されている。

【００５１】前記読取り部H_Rは、下から下部シールド層５２、ギャップ層５５、磁気抵抗効果素子５３、および上部シールド層５１から成る。前記磁気抵抗効果素子５３は、異方性磁気抵抗効果（ＡＭＲ）素子、巨大磁気抵抗効果（ＧＭＲ）素子、トンネル型磁気抵抗効果（ＴＭＲ）素子などである。

【００５２】前記上部シールド層５１の上には、Al_2O_3またはSiO_2などの無機材料による非磁性絶縁層３１が形成されて、前記非磁性絶縁層３１の上に本発明の記録用の垂直磁気記録ヘッドＨが設けられている。そして垂直磁気記録ヘッドＨは無機非磁性絶縁材料などで形成された保護層１３により被覆されている。そして前記垂直磁気記録ヘッドＨの記録媒体との対向面Ｈ１ａは、前記スライダ３０の対向面３０ａとほぼ同一面である。

【００５３】前記垂直磁気記録ヘッドＨでは、パーマロイ（Ｎｉ－Ｆｅ）などの強磁性材料がメッキされて補助磁極層２１が形成されている。なお前記上部シールド層５１が前記補助磁極層２１として兼用されていてもよい。前記非磁性絶縁層３１は、前記補助磁極層２１の下（補助磁極層２１とスライダ３０の側端面３０ｂとの間）および前記補助磁極層２１の周囲に形成されている。そして図１に示すように、補助磁極層２１の表面（上面）２１ａと前記非磁性絶縁層３１の表面（上面）３１ａとは同一の平面上に位置している。

【００５４】図１に示すように、前記対向面Ｈ１ａよりもハイト方向後方（図示Ｙ方向）では、前記補助磁極層２１の表面２１ａ上にＮｉ－Ｆｅなどの接続層２５が形成されている。

【００５５】前記接続層２５の周囲において、前記補助磁極層２１の表面２１ａおよび前記非磁性絶縁層３１の表面３１ａ上に、Al_2O_3などの絶縁下地層２６が形成されて、この絶縁下地層２６の上にＣｕなどの導電性材料によりコイル層２７が形成されている。このコイル層２７はフレームメッキ法などで形成されたものであり、前記接続層２５の周囲に所定の巻き数となるように螺旋状にパターン形成されている。コイル層２７の巻き中心側の接続端２７ａ上には同じくＣｕなどの導電性材料で形成された底上げ層７７が形成されている。

【００５６】前記コイル層２７および底上げ層７７は、レジスト材料などの有機材料の絶縁層３２で被覆されており、さらに絶縁層３３で覆われている。

【００５７】前記絶縁層３３は無機絶縁材料で形成されることが好ましく、前記無機絶縁材料としては、ＡｌＯ、Al_2O_3、SiO_2、Ta_2O_5、ＴｉＯ、ＡｌＮ、ＡｌＳｉＮ、ＴｉＮ、ＳｉＮ、Si_3N_4、ＮｉＯ、ＷＯ、WO_3、ＢＮ、ＣｒＮ、ＳｉＯＮのうち少なくとも１種以上を選択できる。

【００５８】そして前記接続層２５の表面（上面）２５ａ、底上げ層７７の表面（上面）７７ａ、および絶縁層３３の表面（上面）３３ａは、同一面となるように加工されている。このような平坦化加工は後述の製造方法で説明するように、ＣＭＰ技術などを用いて行なわれる。

【００５９】この第１実施形態では、前記絶縁層３３の上に、ヨーク層３５が形成されている。図１に示すように前記ヨーク層３５の前端面３５ａは、前記対向面Ｈ１

ａよりもハイト方向（図示Ｙ方向）後方に形成されている。また前記ヨーク層３５の基端部３５ｃは、前記接続層２５の上面に形成され、前記基端部３５ｃと接続層２５とが磁気的に接続された状態になっている。前記ヨーク層３５の下の絶縁層３３は平坦化面で形成されているので、前記ヨーク層３５をパターン精度良く形成することができる。

【００６０】また本発明では前記ヨーク層３５の前端面３５ａは、下面から上面にかけて（図示Ｚ方向）、ハイト方向（図示Ｙ方向）に傾く傾斜面あるいは湾曲面となっている。

【００６１】また図１に示すように、前記底上げ層７７の表面７７ａにはリード層３６が形成され、リード層３６から前記底上げ層７７およびコイル層２７に記録電流の供給が可能となっている。なお、前記リード層３６は、前記ヨーク層３５と同じ材料で形成でき、前記ヨーク層３５とリード層３６を、同時にメッキで形成することが可能である。

【００６２】また図１に示すように、前記ヨーク層３５よりも前記対向面Ｈ１ａ側に位置する絶縁層３３上から前記ヨーク層３５上にかけてメッキ下地層７１を介してＮｉＦｅ等の磁性材料で形成された主磁極層２４が形成されている。さらに非磁性層４０が、前記主磁極層２４上に重ねられて形成されている。そして前記主磁極層２４及び非磁性層４０の前端面２４ａ，４０ａは共に前記対向面Ｈ１ａから現れている。

【００６３】なお図１に示す実施形態では、前記主磁極層２４及びヨーク層３５は、前記対向面Ｈ１ａからハイト方向にかけてＬ３の長さ寸法で形成されているが、前記主磁極層２４とヨーク層３５とが一部で重なり、磁気的に接続されていれば、前記長さ寸法Ｌ３は限定されない。したがって、前記主磁極層２４及び非磁性層４０は、ハイト方向にさらに長く形成され、例えば図２のように前記ヨーク層３５の後端面３５ｂと同一位置まで延ばされていても良い。

【００６４】なお図１、２に示すように前記非磁性層４０上及びヨーク層３５上が前記保護層１３によって覆われている。

【００６５】なお図１及び図２のように主磁極層２４の上に非磁性層４０が重ねられていると、前記主磁極層２４の下以外に形成されたメッキ下地層７１を除去する工程時に、前記主磁極層２４の高さ寸法を減少させることなく前記メッキ下地層７１を除去でき、また前記メッキ下地層７１を除去した際に前記主磁極層２４のトラック幅方向（図示Ｘ方向）の両側端面に前記メッキ下地層７１の構成材料が付着することがあるが、この場合でも前記主磁極層２４の高さ寸法を減少させることなく、前記付着膜を除去できる。また前記主磁極層２４の両側端面を削ることによって前記主磁極層２４のトラック幅Ｔｗを狭くでき、狭トラック化に対応可能な垂直磁気記録ヘッドを製造できるが、このときでも前記主磁極層２４の高さ寸法を減少させることなく、前記主磁極層２４の狭トラック化を図ることが可能である。

【００６６】なお前記非磁性層４０は非磁性金属材料で形成されていることが好ましい。前記非磁性金属材料には、ＮｉＰ、ＮｉＣｕ、ＮｉＭｎ、ＮｉＷ、ＮｉＢ、Ｐｄ、Ｒｈ、Ｒｕ、Ａｕ、Ｃｕを選択できる。この中でもＮｉＰを選択することが好ましい。前記非磁性層４０はＮｉＰであると、製造上の連続メッキ容易性に加えて、耐熱性に優れ主磁極層２４との密着性も良い。また主磁極層２４との硬さも同等とすることができるので、後述するイオンミリング等による非磁性層４０と主磁極層２４の加工量も同等とすることができ加工性を向上させることができる。

【００６７】また非磁性層４０はＮｉＰ合金であって元素Ｐの濃度は８質量％以上で１５質量％以下であることが好ましい。これにより例えば発熱等の外的要因に対しても安定して非磁性であることが可能である。また、ＮｉＰ合金等の非磁性層４０の合金組成の測定は、ＳＥＭやＴＥＭ等の組合わされたＸ線分析装置や波形分散形線分析装置等で特定可能である。

【００６８】なお上記非磁性金属材料を選択する理由は、メッキ形成される主磁極層２４上に前記非磁性層４０を連続してメッキ形成でき、製造工程の簡略化を図ることができるからである。

【００６９】図３は本発明における別の実施形態を示す垂直磁気記録ヘッドを装備した磁気ヘッドの縦断面図である。

【００７０】図３の実施形態は図１の異なり、前記主磁極層２４の上面に非磁性層４０が重ねられて設けられていない。このため図３では上記した非磁性層４０を設けたことによる効果を得ることはできないが、この実施形態においても前記ヨーク層３５の前端面３５ａは下面から上面にかけてハイト方向（図示Ｙ方向）に傾く傾斜面あるいは湾曲面で形成されることで、後述する本発明の効果を得ることが可能である。

【００７１】次に図１及び図２における主磁極層２４及び非磁性層４０の前端面２４ａ，４０ａの形状について説明する。

【００７２】図４，５に示すように、前記絶縁層３３と主磁極層２４との間にはメッキ下地層７１が形成されている。前記主磁極層２４は前記メッキ下地層７１上からメッキ成長して形成されたものであり、前記主磁極層２４の高さ寸法Ｈ１はある所定値に設定されている。

【００７３】図４，５に示すように、前記主磁極層２４の前端面２４ａの両側端面２４ｄ，２４ｄは、下面から上面に向かう（図示Ｚ方向）にしたがってトラック幅方向（図示Ｘ方向）の幅寸法が徐々に広がる形状で形成されている。図４のように前記両側端面２４ｄ，２４ｄは傾斜面、あるいは図５に示すような湾曲面で形成されて

いることが好ましい。

【００７４】さらに図４，５に示すように、前記主磁極層２４上に形成された非磁性層４０の前端面４０ａも下面から上面に向かうにしたがってトラック幅方向の幅寸法が徐々に広がる形状で形成されている。また図４，５に示すように前記前端面４０ａの両側端面４０ｄ，４０ｄは、前記主磁極層２４の両側端面２４ｄ，４０ｄと連続面とされ、よって図４では前記ヨーク層４０の前端面４０ａの両側端面４０ｄは傾斜面となっており、また図５では前記前端面４０ａの両側端面４０ｄは湾曲面となっている。

【００７５】なお図４，５に示すように前記主磁極層２４の上面（トレーリング側の端面）２４ｇのトラック幅方向の幅寸法でトラック幅Ｔｗが規制される。

【００７６】なお図３のように前記主磁極層２４の上に非磁性層４０が重ねられていない場合も、前記主磁極層２４の前端面２４ａは下面から上面にかけてトラック幅方向（図示Ｘ方向）の幅寸法が徐々に広がる形状であり、このとき前記前端面２４ａの両側端面２４ｄ，２４ｄは傾斜面あるいは湾曲面であることが好ましい。

【００７７】このように前記主磁極層２４の前端面２４ａの両側端面２４ｄ，２４ｄが傾斜面あるいは湾曲面とされ、前記前端面２４ａの形状が略逆台形状であると、実際に記録媒体に記録を行うとき、図１０の破線で示すようにスキュー角を生じたとしても、（ｉｉｉ）で示す前記端面２４ｄが記録トラック幅Ｔｗ１から側方へ斜めに大きくはみ出すことがない。よって前記両側端面２４ｄによるフリンジングを防止できるようになり、オフトラック性能の向上を図ることができる。

【００７８】一方、図３３は図２７あるいは図２９に示す従来の主磁極層５の正面図であるが、図３３のように前記主磁極層５の端面５ａが正方形または長方形であると、主磁極層５の端面５ａが、記録媒体の移動接線方向（図示Ｚ方向）に対してスキュー角を有すると、破線で示すように主磁極層の側辺５ｂがトラック幅Ｔｗ１内に斜めの漏れ磁界を与えてフリンジングＦが発生し、オフトラック性能の低下を招いてしまう。

【００７９】よって本発明のように前記主磁極層２４の前端面２４ａは略逆台形状であることが良い。

【００８０】次に前記主磁極層２４及びヨーク層３５を真上から見た平面形状について以下に説明する。なお以下に説明する平面図は図１ないし図３に示す垂直磁気記録ヘッドのいずれにも適用できるものである。

【００８１】図６の平面図に示すように、前記ヨーク層３５は、対向面Ｈ１ａ側である前方領域３５ｄでトラック幅方向の幅寸法Ｗｙが細くなり、後方領域３５ｅでトラック幅方向の幅寸法が徐々に大きくなる平面形状である。そして、前記前方領域３５ｄ上に主磁極層２４が重ねられている。なお前記前方領域３５ｄのトラック幅方向（図示Ｘ方向）における幅寸法Ｗｙは、トラック幅Ｔｗよりも広い幅寸法で形成される。

【００８２】図６に示すように前記主磁極層２４は前端面２４ａの上面（トレーリング側の端面）がトラック幅Ｔｗで規制され、その幅寸法を保ってあるいはやや幅広になってハイト方向後方に向けて短い長さ寸法で形成されている。

【００８３】なお本発明では、前記対向面Ｈ１ａに露出する前記主磁極層２４の前端面２４ａが、前記補助磁極層２１の前端面２１ｂの面積よりも大きいことが必要で、例えば図６に示すように、補助磁極層２１のトラック幅方向の幅寸法Ｗｒは、前記トラック幅Ｔｗよりも十分に大きい幅寸法で形成されることが好ましい。

【００８４】図７では、前記ヨーク層３５が前記前方領域３５ｄを有することなく、ハイト方向（図示Ｙ方向）に至るにしたがって幅寸法Ｗｙが徐々に広がる形状である。そして前記ヨーク層３５上に主磁極層２４が重ねられている。

【００８５】図７に示すように前記主磁極層２４は前端面２４ａの上面（トレーリング側のの端面）がトラック幅Ｔｗで規制され、その幅寸法を保ってあるいはやや幅広になってハイト方向後方に向けて短い長さ寸法で形成されている。

【００８６】図８では、前記ヨーク層３５の形状は図７と同じであるが、前記主磁極層２４の後方領域２４ｅが幅寸法が徐々に広がる形状であり、この後方領域２４ｅとヨーク層３５とが重なり合っている。ただし、前記ヨーク層３５がさらに対向面側Ｈ１ａに寄って形成され、前記主磁極層２４の幅細形状の前方領域２４ｆの一部も前記ヨーク層３５と重なり合っていてもよい。これにより前記ヨーク層３５から前記主磁極層２４への磁束の導入をスムーズにでき、高記録密度化に対応可能な垂直磁気記録ヘッドを製造することができる。

【００８７】また前記ヨーク層３５に図６に示すような前方領域３５ｄが形成されていても良い。

【００８８】図９では、前記ヨーク層３５の形状は、図７及び図８と同じであるが、前記主磁極層２４の後方領域２４ｅが幅寸法が徐々に広がる形状であり、さらにこの後方領域２４ｅは、ハイト方向（図示Ｙ方向）に長く延びて形成されている。前記後方領域２４ｅの後端は、図２のように前記ヨーク層３５の後端面３５ｂと同一面にまで延ばされていても良い。

【００８９】また前記ヨーク層３５に図６に示すような前方領域３５ｄが形成されていても良い。さらには前記主磁極層２４には、漸次的に幅寸法が広がる後方領域２４ｅが形成されず、ハイト方向に向けてトラック幅Ｔｗを保って、あるいはハイト方向に向けて前記トラック幅Ｔｗよりもやや幅広になった幅細の前方領域２４ｆがハイト方向に長く延ばされていても良い。

【００９０】上記した図６ないし図９に示す平面図では、いずれも前記ヨーク層３５にはハイト方向に至るに

したがって幅寸法Ｗｙが漸次的に広がる領域が形成されており、特に前記ヨーク層３５と主磁極層２４とが重なる位置において、前記ヨーク層３５のトラック幅方向の幅寸法が、前記主磁極層２４のトラック幅方向の幅寸法よりも広くなっている。

【００９１】また前記ヨーク層３５の膜厚は前記主磁極層２４の膜厚と同程度か、あるいは前記ヨーク層３５の膜厚が前記主磁極層２４の膜厚よりも大きく形成されている。

【００９２】従って前記ヨーク層３５と主磁極層２４とが重なる位置において、前記ヨーク層３５の前記対向面Ｈ１ａと平行な方向への断面積は、前記主磁極層２４の前記対向面Ｈ１ａと平行な方向への断面積よりも大きくなっている。これにより前記ヨーク層３５から前記主磁極層２４に適切に記録磁界を導くことができ、磁束の通過効率が良くなって、オーバーライト特性を向上できる。

【００９３】また図１ないし図３のように主磁極層２４とヨーク層３５とを別々に形成し、前記ヨーク層３５の上に主磁極層２４を重ねる構造である場合、前記主磁極層２４の幅細で形成された前方領域２４ｆを長く延ばして形成する方が、前記前方領域２４ｆの全体の幅寸法をほぼトラック幅Ｔｗでパターン精度良く形成できて好ましい。さらにかかる場合、前記ヨーク層３５をできる限り対向面Ｈ１ａ側に寄せて形成することで、前記主磁極層２４の磁気飽和を抑制でき、前記主磁極層２４に磁束を集中させることができる。

【００９４】なお図６ないし図９は一例であり、主磁極層２４及びヨーク層３５の平面形状がこれら平面形状に限定されるものではない。本発明では、前記主磁極層２４とヨーク層３５とが重なる位置において、前記ヨーク層３５の前記対向面Ｈ１ａと平行な方向への断面積が、前記主磁極層２４の前記対向面Ｈ１ａと平行な方向への断面積よりも大きくなっていれば、如何なる平面形状で形成されていてもよい。

【００９５】ところで本発明では図１ないし図３のいずれの実施形態においても、前記ヨーク層３５の前端面３５ａは下面から上面にかけてハイト方向に傾く傾斜面あるいは湾曲面で形成されている。

【００９６】このような前端面３５ａの形成方法については、後の製造方法で詳しく説明するが、これにより以下の効果を得ることができる。

【００９７】すなわち本発明では、前記ヨーク層３５よりも前方に位置する絶縁層３３上から前記ヨーク層３５上にかけて形成される主磁極層２４をレジスト層を用いて形成するとき、前記レジスト層に主磁極層２４形成のための抜きパターンを露光現像によって形成するが、この際、前記ヨーク層３５の前端面３５ａがなだらかな傾斜面あるいは湾曲面であると、前記絶縁層３３上からヨーク層３５上にかけて形成されるレジスト層をほぼ一定の膜厚で形成できるため、前記抜きパターン内のレジスト層を上面から下面まで適切に露光現像でき、従来のように前記抜きパターン内にレジスト溜りが発生することが無い。

【００９８】従って本発明では、前記抜きパターン内一面にメッキ下地層７１を露出させ、前記メッキ下地層７１上に適切に所定形状の主磁極層２４をメッキ成長させることができる。

【００９９】また上記のように前記ヨーク層３５の前端面３５ａがなだらかな傾斜面あるいは湾曲面で形成されていると、前記主磁極層２４を形成するためのレジスト層の膜厚をほぼ均一に形成できることからパターン精度を向上させることができ、従って前記主磁極層２４をパターン精度良く形成することが可能である。

【０１００】特に上記したように前記主磁極層２４の前記対向面Ｈ１ａに現れる前端面２４ａは、その上面（トレーリング側の端面）のトラック幅方向の寸法がトラック幅Ｔｗとして規制されるが、このトラック幅Ｔｗを高精度に所定寸法で設定することが可能になる。従って本発明では狭トラック化に対応可能な垂直磁気記録ヘッドを製造できる。

【０１０１】また本発明では、前記ヨーク層３５の前端面３５ａがなだらかな傾斜面あるいは湾曲面となっていることで、前記ヨーク層３５から前記主磁極層２４には、スムーズに磁束が導かれ、磁束の通過効率を向上させることができる。すなわち本発明では前記ヨーク層３５の前端面３５ａから漏れる磁束を減少させ、前記主磁極層２４に適切に磁束を集中させることができ、今後の高記録密化に適切に対応可能な垂直磁気記録ヘッドを製造することができる。

【０１０２】また本発明では、上記したように前記絶縁層３３の上面３３ａと接続層２５の上面２５ａはＣＭＰ技術などによって同一面とされた平坦化面となっている。

【０１０３】従って前記絶縁層３３の上にヨーク層３５さらには主磁極層２４をパターン精度良く形成することが可能になる。

【０１０４】また本発明では、前記主磁極層２４及びヨーク層３５を別々に形成することが可能であるから、前記主磁極層２４とヨーク層３５とを異なる磁性材料で形成することも可能である。かかる場合、前記主磁極層２４の飽和磁束密度が、ヨーク層３５の飽和磁束密度よりも高くなるように磁性材料を選択することが好ましい。主磁極層２４をヨーク層３５よりも飽和磁束密度の高い磁性材料で形成しておくと、幅寸法Ｔｗと膜厚の小さい主磁極層２４からハード膜Ｍａに対して密度の高い磁束φを垂直方向へ与えることが可能となり、オーバーライト特性が向上するようになる。

【０１０５】なお前記主磁極層２４及びヨーク層３５には、Ｎｉ－Ｆｅ、Ｃｏ－Ｆｅ、Ｎｉ－Ｆｅ－Ｃｏなどの

磁性材料が選択されるが、主磁極層２４及びヨーク層３５に同じ磁性材料を選択する場合には、組成比を変えることで飽和磁束密度に差を出すことが可能である。

【０１０６】なお図１ないし図３に示す垂直磁気記録ヘッドでは、リード層３６を介してコイル層２７に記録電流が与えられると、コイル層２７を流れる電流の電流磁界によって補助磁極層２１とヨーク層３５に記録磁界が誘導される。図１ないし３に示すように、対向面Ｈ１ａでは、前記主磁極層２４の前端面２４ａと補助磁極層２１の前端面２１ｂからの漏れ記録磁界が、記録媒体Ｍのハード膜Ｍａを貫通しソフト膜Ｍｂを通過する。前記主磁極層２４の前端面２４ａの面積が補助磁極層２１の前端面２１ｂの面積よりも十分に小さいために、前記主磁極層２４の前端面２４ａに洩れ記録磁界の磁束φが集中し、この集中している磁束φにより前記ハード膜Ｍａが垂直方向へ磁化されて、磁気データが記録される。

【０１０７】次に本発明の垂直磁気記録ヘッドの製造方法について以下に説明する。図１１から図２６は本発明における垂直磁気記録ヘッドの製造工程を示す工程図である。なお図１１から図１３は図１ないし図３に示す垂直磁気記録ヘッドの共通の製造工程を示している。

【０１０８】図１１に示す工程では、非磁性絶縁層３１上に磁性材料製の補助磁極層２１を形成した後、前記補助磁極層２１のハイト方向（図示Ｙ方向）後方も前記非磁性絶縁層３１で埋め、さらに前記補助磁極層２１および非磁性絶縁層３１の上面をＣＭＰ技術などを用いて平坦化加工する。

【０１０９】次に前記補助磁極層２１のハイト方向（図示Ｙ方向）後方に、磁性材料製の接続層２５をメッキ形成し、さらに前記補助磁極層２１上面から接続層２５の上面にかけて無機絶縁材料をスパッタして絶縁下地層２６を形成する。

【０１１０】次に図１２に示すように前記絶縁下地層２６の上にフレームメッキ法によりコイル層２７を形成し、さらに底上げ層７７を同じくメッキにより形成する。このときコイル層２７は、前記接続層２５の高さよりも十分に低い位置に形成する。そして前記コイル層２７と底上げ層７７を有機材料の絶縁層３２で覆い、さらに、無機絶縁材料をスパッタして、全ての層を覆う絶縁層３３を形成する。

【０１１１】次に、図１２の状態に成膜された各層に対して、図示上方からＣＭＰ技術などを用いて研磨加工を行なう。この研磨加工は、前記絶縁層３３、接続層２５および底上げ層７７の全てを横断する水平面（Ｌ－Ｌ面）の位置まで行なう。

【０１１２】前記研磨加工の結果、図１３に示すように、接続層２５の表面２５ａ、絶縁層３３の表面３３ａおよび底上げ層７７の表面７７ａが全て同一面となるように加工される。

【０１１３】ここまでが各実施形態において共通する製造工程である。次に図１に示す構造の垂直磁気記録ヘッドの製造方法について説明する。

【０１１４】図１４は平面図であり、平坦化された絶縁層３３の上全面にメッキ下地層７２をスパッタ成膜する。次に前記メッキ下地層７２の上にレジスト層８０を形成し、前記レジスト層８０にヨーク層３５形状のパターン８０ａを残し、それ以外のレジスト層を除去する。なおレジスト層８０の種類によって露光現像された部分が除去されるものと、露光現像されない部分が除去されるものとがあるので、露光現像された部分が除去されるレジスト層８０を用いた場合には、前記パターン８０ａ以外のレジスト層８０を露光現像して、その部分を除去する。また露光現像されない部分が除去されるレジスト層８０を用いた場合には、前記パターン８０ａ内を露光現像し、露光現像されていないレジスト層８０を除去する。これによって図１４に示すパターン８０ａのレジスト層８０を残すことができる。

【０１１５】なお前記パターン８０ａは、ヨーク層３５が形成される領域のヨークパターン８０ｃと、その後方に位置しメッキ通電用のコモンパターン８０ｄとから構成される。

【０１１６】なお前記パターン８０ａは、その前端面８０ｂが前記対向面Ｈ１ａよりもハイト方向（図示Ｙ方向）後方に位置し、また前記パターン８０ａのヨークパターン８０ｃは前記接続層２５にまで延びて形成されている。

【０１１７】次に前記レジスト層８０によって覆われていないメッキ下地層７２をイオンミリングで除去した後、前記レジスト層８０を除去する。

【０１１８】これによって前記絶縁層３３の上には、パターン８０ａの形状のメッキ下地層７２が残される。

【０１１９】次に図１５は平面図でありこの工程では、前記コモンパターン８０ｄ上をレジスト層７６で覆う。このときの縦断面図は図１８に示されている。そして前記ヨークパターン８０ｃのメッキ下地層７２上にヨーク層３５をメッキ成長させる。

【０１２０】あるいは次の方法によってヨーク層３５を形成してもよい。図１６は平面図でありこの工程では、前記絶縁層３３の上にレジスト層７３を形成する。さらに前記レジスト層７３にヨーク層３５の平面形状となる抜きパターン７３ａを露光現像により形成する。前記抜きパターン７３ａは、ヨーク層３５が形成される領域のヨークパターン７３ｃと、その後方に位置するメッキ通電用のコモンパターン７３ｄとで構成される。前記抜きパターン７３ａは、その前端面７３ｂが前記対向面Ｈ１ａよりもハイト方向（図示Ｙ方向）後方に位置し、また前記抜きパターン７３ａのヨークパターン７３ｃは前記接続層２５にまで延びて形成されている。

【０１２１】そして、前記抜きパターン７３ａ内にメッキ下地層７２をスパッタ成膜し、前記レジスト層７３を

除去する。

【０１２２】図１７に示す工程では前記コモンパターン７３ｄ上をレジスト層７４で覆う。このときの縦断面図は図１８に示されている。そして前記レジスト層７４に覆われていない前記ヨークパターン７３ｃ上に形成されたメッキ下地層７２上にヨーク層３５をメッキ成長させる。

【０１２３】次に図１５及び図１７工程の後、前記レジスト層７６、７４を除去し、さらにコモンパターン８０ｄ、７３ｄ上のメッキ下地層７２を除去すると、この時点での垂直磁気記録ヘッドの縦断面図は図１９のようになる。

【０１２４】図１９に示すように、前記メッキ下地層７２上にメッキ形成されたヨーク層３５は、その前端面３５ａはなだらかに丸みを帯びた形状であり、あるいはなだらかな傾斜面となる。このように前記前端面３５ａがなだらかな傾斜面あるいは湾曲面となるのは、図１５あるいは図１７工程時に、前記ヨークパターン７３ｃ上のメッキ下地層７２の周囲がレジスト層などによって囲まれておらず、前記ヨークパターン７３ｃの周囲は開放されているからである。

【０１２５】図１５及び図１７、あるいは図１８を詳しく見てみると、前記絶縁層３３の上に形成されたメッキ下地層７２の周囲は、コモンパターン７５ｄ上を除いて、レジスト層７４，７６などによって囲まれていないことがわかる。

【０１２６】このように前記メッキ下地層７２の周囲がレジスト層などによって囲まれておらず開放されている場合、前記メッキ下地層７２上にメッキ成長するヨーク層３５の端面は、なだらかに丸みを帯びながら成長していき、傾斜面あるいは湾曲面となるのである。

【０１２７】なお本発明では、少なくとも前記メッキ下地層７２の前端面７２ｂよりも前方領域がレジスト層によって覆われていなければ良く、例えば前記メッキ下地層７２のトラック幅方向（図示Ｘ方向）における両側端面がレジスト層によって覆われていてもよい。かかる場合、少なくとも前記メッキ下地層７２上にメッキ成長するヨーク層３５はその前端面３５ａが下面から上面にかけてハイト方向に傾く傾斜面あるいは湾曲面として形成される。

【０１２８】また図１９には示されていないが、前記底上げ層７７の上面７７ａにも図１４ないし図１７に示す工程と同じ工程時にリード層３６をメッキ形成することが好ましい。

【０１２９】次に図２０は平面図であり、この工程では、前記ヨーク層３５及びその周囲に広がる絶縁層３３上にメッキ下地層７１をスパッタ成膜し、その上にレジスト層７５を形成し、前記レジスト層７５に主磁極層２４の形成のための抜きパターン７５ａを露光現像により形成する。

【０１３０】図２０に示すように前記抜きパターン７５ａの前端面７５ｂは前記対向面Ｈ１ａと同一面上に形成され、さらに前記抜きパターン７５ａは、前記ヨーク層３５上にまで延びて形成されている。またこの工程では前記抜きパターン７５ａは、その後端面７５ｄが一点鎖線で示すようにさらにハイト方向（図示Ｙ方向）後方に延びて形成されていてもかまわない。

【０１３１】また図２１は図２０に示すＭ－Ｍ線から垂直磁気記録ヘッドを切断し、矢印方向から見た縦断面図である。

【０１３２】図２１に示すように、前記レジスト層７５に形成された抜きパターン７５ａ内には、従来のようにレジスト溜りが無く、前記抜きパターン７５ａ内では適切にメッキ下地層７１が露出した状態になっている。

【０１３３】これは上記のように前記ヨーク層３５の前端面３５ａがなだらかな傾斜面あるいは湾曲面となっているからであり、これにより前記ヨーク層３５よりも前方の絶縁層３３上からヨーク層３５上にかけて形成されるレジスト層７５の膜厚をほぼ均一にでき、前記レジスト層７５に形成される抜きパターン７５ａ内のレジスト層７５を上面から下面まで適切に露光現像して除去することが可能となっている。

【０１３４】次に本発明における前記レジスト層７５は、前記対向面Ｈ１ａ側から見ると図２２に示す形状となっている。

【０１３５】図２２に示すように、前記レジスト層７５に形成された抜きパターン７５ａの内側端面７５ｅ，７５ｅは、下面から上面にかけて（図示Ｚ方向）、トラック幅方向（図示Ｘ方向）の幅寸法が徐々に広がって形成されている。前記内側端面７５ｅは、図２２に示すように湾曲面で形成されていてもよいし、傾斜面で形成されていてもよい。

【０１３６】このような形状の抜きパターン７５ａを前記レジスト層７５に形成するには、前記レジスト層７５を塗布した後、露光現像で前記抜きパターン７５ａを形成し、さらに熱処理によって前記抜きパターン７５ａの内側側面７５ｅをだれさせることで、前記内側側面７５ｅを傾斜面あるいは湾曲面に形成できる。

【０１３７】次に図２３、２４に示すように、前記抜きパターン７５ａ内に露出した前記メッキ下地層７１上に主磁極層２４をメッキ成長させる。このとき図２３のように前記主磁極層２４をある所定の膜厚Ｈ１までメッキ成長させる。

【０１３８】さらに本発明では前記主磁極層２４上にＮｉＰ等の非磁性金属材料からなる非磁性層４０をメッキ成長させる。そして前記レジスト層７５を除去する。

【０１３９】本発明では図２１で見たように前記抜きパターン７５ａ内にはレジスト溜りが無く、メッキ下地層７１が前記抜きパターン７５ａ内一面に適切に露出した状態になっている。したがって前記主磁極層２４は前記

メッキ下地層７１上から適切にメッキ成長され、所定形状の前記主磁極層２４を形成することが可能である。

【０１４０】また本発明では、前記ヨーク層３５の前端面３５ａがなだらかな傾斜面あるいは湾曲面となっていることにより、前記レジスト層７５をほぼ均一な膜厚で形成できるから、前記ヨーク層３５上に形成される主磁極層２４の抜きパターン７５ａを高精度にパターン形成しやすい。

【０１４１】特に前記主磁極層２４の前端面２４ａの上面（トレーリング側の端面）のトラック幅方向の寸法は微小なトラック幅Ｔｗとして規制されるが、上記のように高いパターン精度によって前記トラック幅Ｔｗを所定の大きさで形成でき、今後の狭トラック化に対応可能な垂直磁気記録ヘッドを製造することが可能である。

【０１４２】図２５は、前記レジスト層７５を除去した状態を示す正面図である。図２５に示すように、前記メッキ下地層７１の上には、トラック幅方向の幅寸法が下面から上面にかけて徐々に広がるように両側端面が傾斜面あるいは湾曲面とされた主磁極層２４及び非磁性層４０が積層されている。

【０１４３】図２５に示すように、前記主磁極層２４の下のみならず他の領域にも前記メッキ下地層７１が形成されているため、主磁極層２４の下以外の前記メッキ下地層７１を除去しなければならない。

【０１４４】図２５に示す工程では、異方性のイオンミリングによって、前記主磁極層２４の下以外に形成された前記メッキ下地層７１を除去する。このとき前記非磁性層４０の上面４０ｅも前記イオンミリングの影響を受けて削られていく。

【０１４５】また図２６に示すように、除去された前記メッキ下地層７１ａの一部は、前記主磁極層２４及び非磁性層４０の両側端面２４ｄ，４０ｄに再付着するため（矢印方向Ｃ）、前記両側端面に付着した付着膜７８，７８を異方性のイオンミリングで除去する。このときも前記非磁性層４０の上面４０ｅは前記イオンミリングの影響を受けて削られていく。なお前記メッキ下地層７１及び付着膜７８の除去は前記メッキ下地層７１が磁性材料で形成されているときに特に有効である。前記付着膜７８が磁性材料であるとトラック幅Ｔｗが広がるからである。一方、前記付着膜７８が非磁性メッキ材料であるときは、前記付着膜７８の除去は特に必要ない。また前記メッキ下地層７１が電気特性に影響を与えない範囲内に形成されている場合には特に前記メッキ下地層７１の除去も必要ない。

【０１４６】上記のように本発明では主磁極層２４の上に非磁性層４０が形成されているため、イオンミリングでメッキ下地層７１及びその付着膜７８を除去するときに、前記非磁性層４０の上面４０ｅが削れるだけで前記主磁極層２４の高さ寸法Ｈ１は減少しない。

【０１４７】また前記主磁極層２４の両側端面２４ｄ，及び非磁性層４０の両側端面４０ｄを異方性のイオンミリングでさらに削って、前記主磁極層２４の上面（トレーリング側の端面）２４ｇの幅寸法で決まるトラック幅Ｔｗを小さくする場合でも、イオミリングで非磁性層４０の上面４０ｅは削られるものの、前記主磁極層２４の高さ寸法Ｈ１は減少しない。

【０１４８】したがって本発明のように主磁極層２４の上に非磁性層４０が重ねられて形成されている場合には、主磁極層２４の高さ寸法Ｈ１を減少させることはなく一定値に保った状態で、メッキ下地層７１ａ、付着膜７８の除去や狭トラック化を実現することが可能である。

【０１４９】なお本発明では前記イオンミリングは、メッキ下地層７１に対して垂直方向から４５°から７０°前後傾いた角度で行なわれることが好ましい。なお４５°以上で６０°以下にすると、メッキ下地層７１ａ、付着膜７８の除去、さらには狭トラック化を1回のイオンミリング工程で行うことが可能であり、製造工程を簡略化できる。

【０１５０】ただしメッキ下地層７１ａの除去工程、付着膜７８の除去工程、および狭トラック化工程を、それぞれ別のミリング角度を有するイオンミリングで行っても良い。

【０１５１】なお本発明では、前記主磁極層２４の高さ寸法Ｈ１は０．２５μｍ以上で０．５μｍ以下程度であることが好ましく、前記主磁極層２４のトラック幅Ｔｗは０．７μｍ以下であることが好ましく、より好ましくは０．５μｍ以下である。

【０１５２】また本発明ではヨーク層３５形成のためのメッキ下地層７２、および主磁極層２４形成のための前記メッキ下地層７１は、磁性メッキ材料であってもよいし、非磁性メッキ材料であってもよい。なお前記主磁極層２４形成のための前記メッキ下地層７１に非磁性の例えばＣｕなどの金属材料を用いた場合、前記主磁極層２４下の周囲に若干延出して前記メッキ下地層７１が残されていてもかまわないので、前記メッキ下地層７１に磁性メッキ材料を用いる場合に比べてエッチング制御を容易にすることができる。

【０１５３】図２に示す垂直磁気記録ヘッドを製造する場合には、図２０に示す工程時においてレジスト層７５に形成される抜きパターン７５ａの後端面７５ｄをさらにハイト方向（図示Ｙ方向）に延ばし（符号７５ｃの領域）、前記後端面７５ｄを前記ヨーク層３５の後端面３５ｂに揃えれば良い。

【０１５４】また図３に示す垂直磁気記録ヘッドを製造する場合には、図２３及び図２４の工程時において、レジスト層７５に形成された抜きパターン７５ａ内に主磁極層２４のみをメッキ成長させれば良い。

【０１５５】なお本発明では、図２２に示すレジスト層７５は、前記対向面Ｈ１ａでのトラック幅方向（図示Ｘ

方向）の内幅寸法が、下面から上面にかけて広がるように形成されていなくても良く、前記主磁極層２４の前端面２４ａが従来と同様に正方形や長方形等の形状で形成されていても本発明の効果を得ることが可能である。

【０１５６】また図１及び図２に示す実施形態では、読取り部H_Rが形成されているが、これが形成されていなくても良い。

【０１５７】

【発明の効果】以上のように本発明では、絶縁層上に形成されるヨーク層の前端面を下面から上面にかけてハイト方向に傾く傾斜面あるいは湾曲面で形成している。

【０１５８】このため前記ヨーク層よりも前方に位置する絶縁層上から前記ヨーク層上にかけて形成される主磁極層をレジスト層を用いて形成するとき、前記レジスト層の膜厚をほぼ均一に形成できるため、前記レジスト層に前記主磁極層形成のための抜きパターンを露光現像で形成したとき、前記抜きパターン内に従来のようなレジスト溜りが発生しない。

【０１５９】従って本発明では、前記抜きパターン内一面にメッキ下地層を露出させ、前記メッキ下地層上に適切に所定形状の主磁極層をメッキ成長させることができる。

【０１６０】また上記のように前記ヨーク層の前端面がなだらかな傾斜面あるいは湾曲面で形成されていると、前記主磁極層を形成するためのレジスト層の膜厚をほぼ均一に形成できることからパターン精度を向上させることができ、従って前記主磁極層をパターン精度良く形成することが可能であり、前記主磁極層の前端面を所定のトラック幅Ｔｗ及び所定形状で形成することができる。

【０１６１】また本発明では、前記ヨーク層の前端面がなだらかな傾斜面あるいは湾曲面となっていることで、前記ヨーク層から前記主磁極層には、スムーズに磁束が導かれ、磁束の通過効率を向上させることができる。すなわち本発明では前記ヨーク層の前端面から漏れる磁束を減少させ、前記主磁極層に適切に磁束を集中させることができ、今後の高記録密化に適切に対応可能な垂直磁気記録ヘッドを製造することができる。

【図面の簡単な説明】

【図１】本発明における第１実施形態の垂直磁気記録ヘッドを備えた磁気ヘッドの縦断面図、

【図２】本発明における第２実施形態の垂直磁気記録ヘッドを備えた磁気ヘッドの縦断面図、

【図３】本発明における第３実施形態の垂直磁気記録ヘッドを備えた磁気ヘッドの縦断面図、

【図４】本発明における垂直磁気記録ヘッドの部分正面図、

【図５】本発明における垂直磁気記録ヘッドの別の部分正面図、

【図６】図１ないし図３の垂直磁気記録ヘッドの平面図、

【図７】図１ないし図３の垂直磁気記録ヘッドの別の平面図、

【図８】図１ないし図３の垂直磁気記録ヘッドの別の平面図、

【図９】図１ないし図３の垂直磁気記録ヘッドの別の平面図、

【図１０】本発明における磁気ヘッドにスキュー角が発生した状態を示す説明図、

【図１１】本発明における垂直磁気記録ヘッドの製造方法を示す一工程図、

【図１２】図１１に示す工程の次に行なわれる一工程図、

【図１３】図１２に示す工程の次に行なわれる一工程図、

【図１４】図１３に示す工程の次に行なわれる一工程図、

【図１５】図１４に示す工程の次に行なわれる一工程図、

【図１６】図１４に代えて、図１３に示す工程の次に行なわれる一工程図、

【図１７】図１６に示す工程の次に行なわれる一工程図、

【図１８】図１５及び図１７工程時のヨーク層が形成されていない段階での縦断面図、

【図１９】図１５及び図１７工程時のヨーク層が形成された段階での縦断面図、

【図２０】図１５、１７、および１９に示す工程の次に行なわれる一工程図、

【図２１】図２０の垂直磁気記録ヘッドをＭ－Ｍ線から切断したときの縦断面図、

【図２２】図２０に示す垂直磁気記録ヘッドの正面図、

【図２３】図２２に示す工程の次に行なわれる一工程図、

【図２４】図２３工程時における垂直磁気記録ヘッドの縦断面図、

【図２５】図２３及び図２４工程時の次に行なわれる一工程図、

【図２６】図２５工程時の次に行なわれる一工程図、

【図２７】従来の垂直磁気記録ヘッドの構造を示す縦断面図、

【図２８】図２７の平面図、

【図２９】改良された従来の垂直磁気記録ヘッドの構造を示す縦断面図、

【図３０】図２９の平面図、

【図３１】図２９の垂直磁気記録ヘッドの製造方法を示す一工程図、

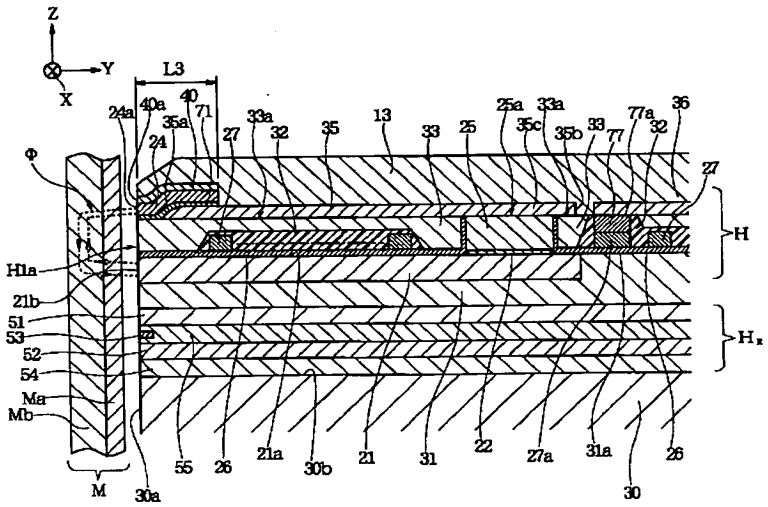
【図３２】図３１に示す工程の次に行なわれる一工程図、

【図３３】従来における磁気ヘッドにスキュー角が発生した状態を示す説明図、

【符号の説明】
Ｈ　垂直磁気記録ヘッド
Ｈ１ａ　対向面
Ｍ　記録媒体
Ｍａ　ハード膜
Ｍｂ　ソフト膜
２１　補助磁極層
２４　主磁極層
２４ａ、３５ａ、４０ａ　前端面
２５　接続層
２７　コイル層
３３　絶縁層
３５　ヨーク層
４０　非磁性層
７３、７４、７５、７６、８０　レジスト層
７１、７２　メッキ下地層

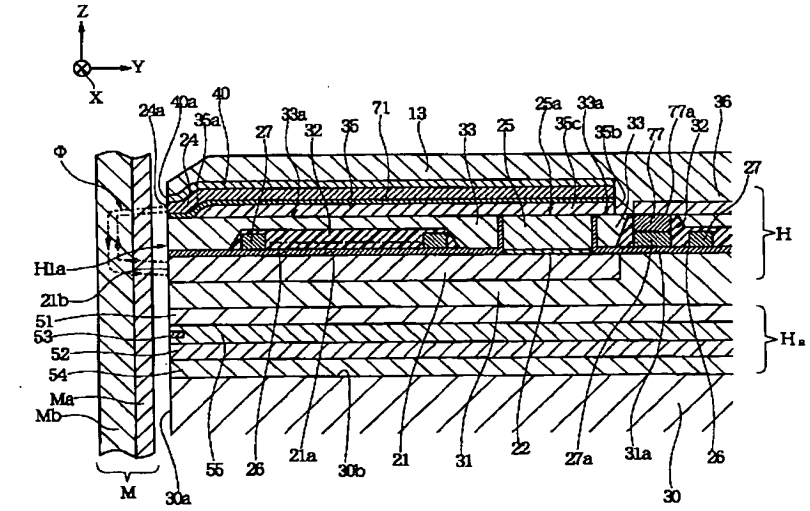
【図１】

図１



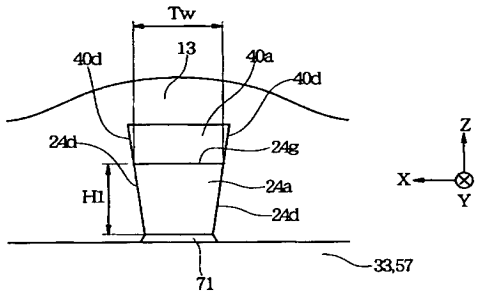
【図２】

図２



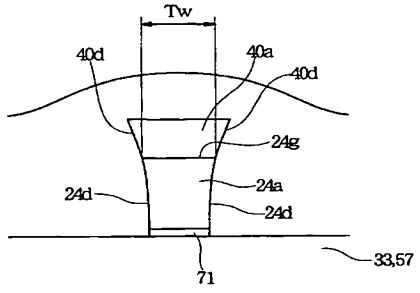
【図４】

図４



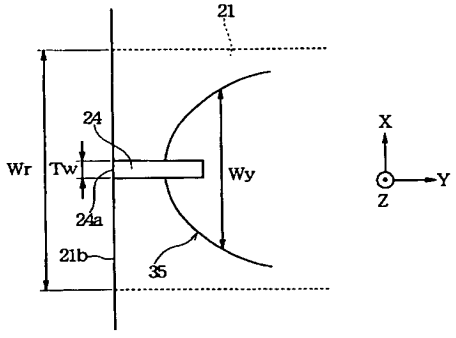
【図５】

図５



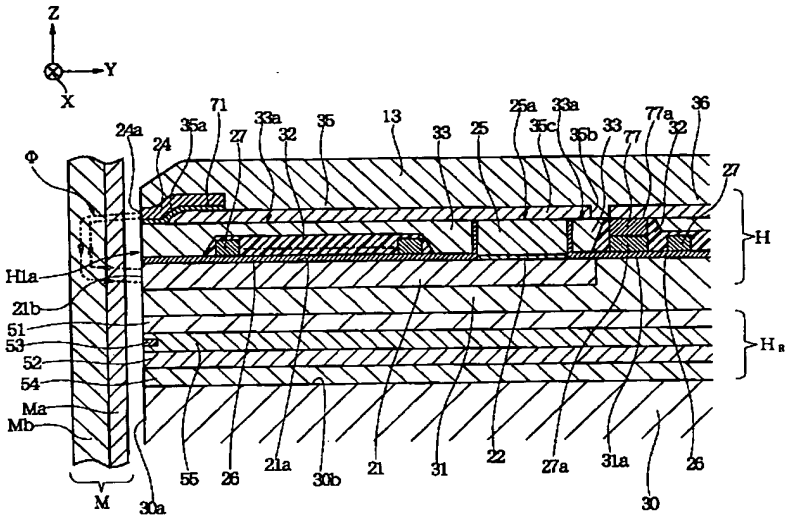
【図７】

図７



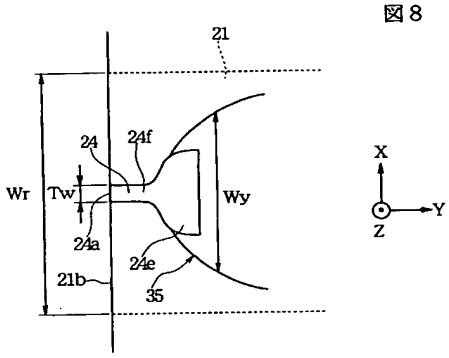
【図３】

図３



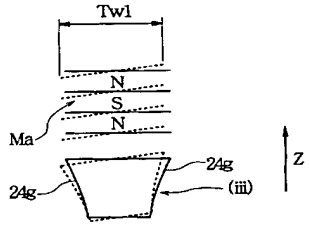
【図８】

図８



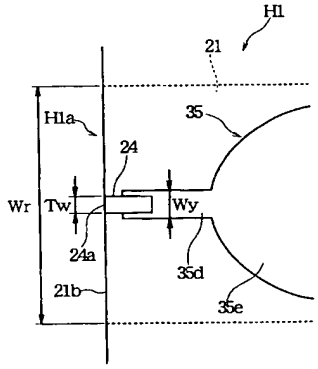
【図１０】

図１０



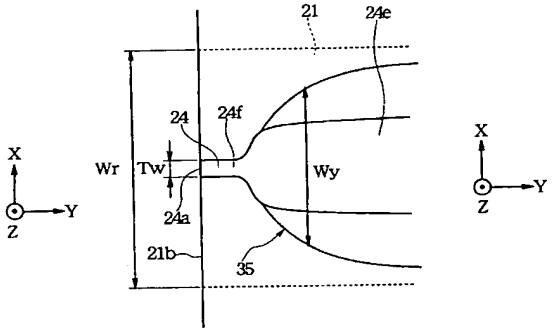
【図６】

図６



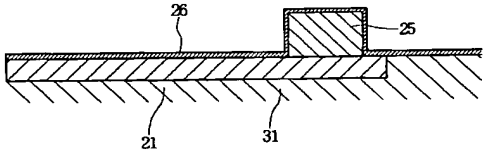
【図９】

図９



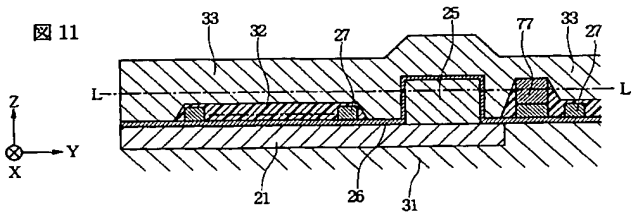
【図１１】

図１１



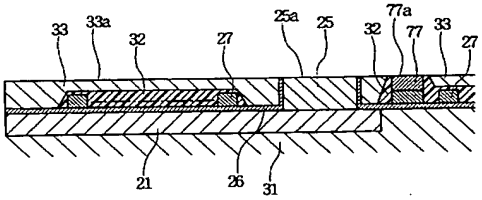
【図１２】

図１２



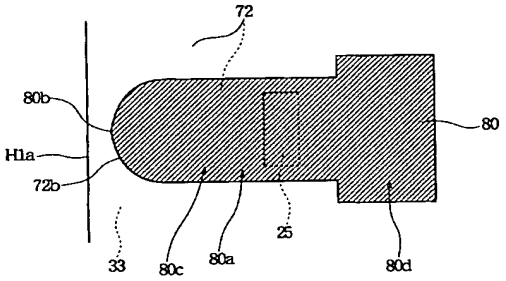
【図１３】

図 13



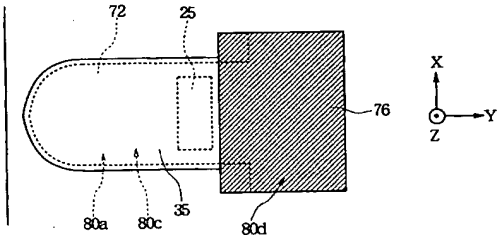
【図１４】

図 14



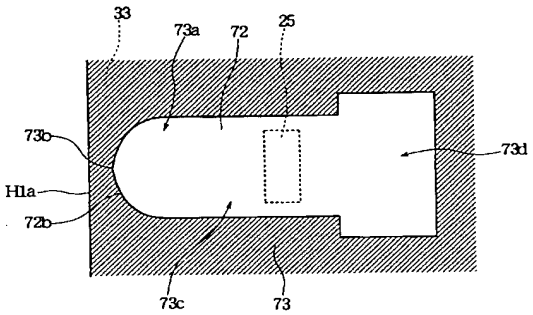
【図１５】

図 15



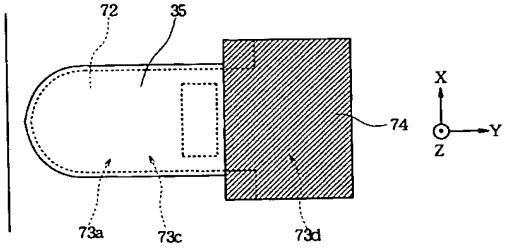
【図１６】

図 16



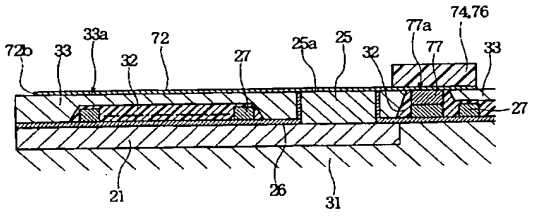
【図１７】

図 17



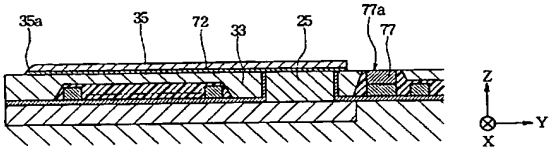
【図１８】

図 18



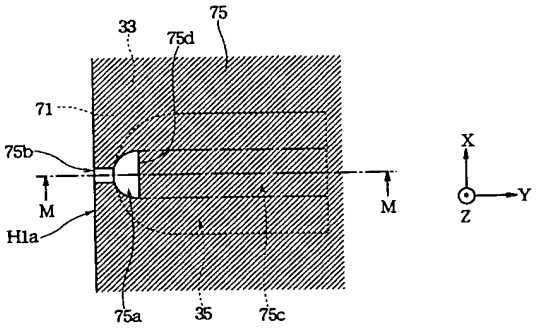
【図１９】

図 19



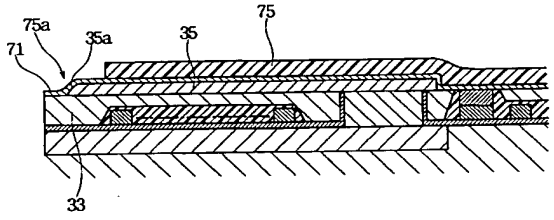
【図２０】

図 20



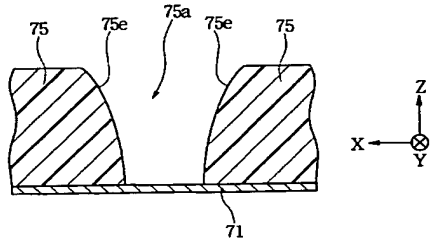
【図２１】

図21



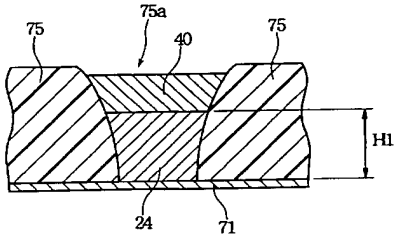
【図２２】

図22



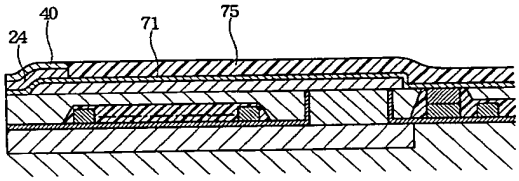
【図２３】

図23



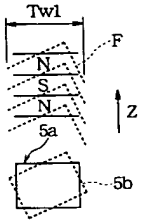
【図２４】

図24



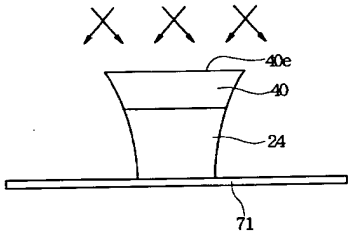
【図３３】

図33



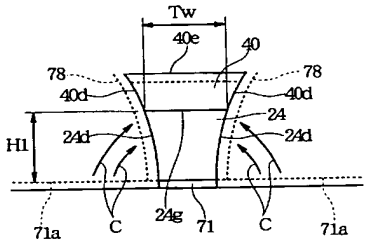
【図２５】

図25



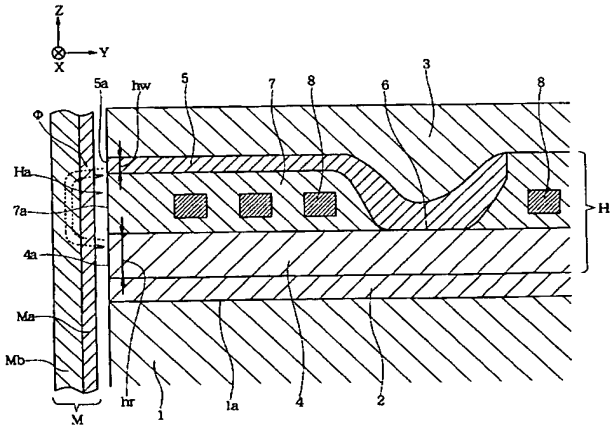
【図２６】

図26



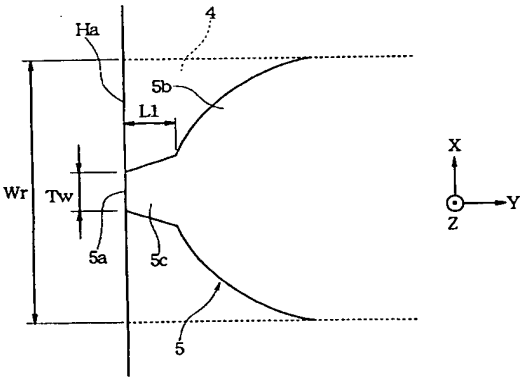
【図２７】

図27



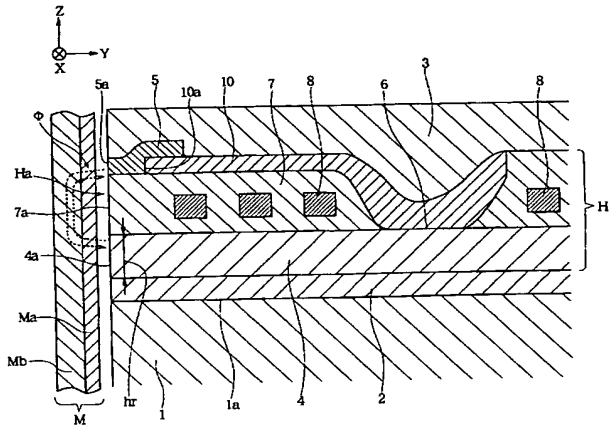
【図２８】

図28



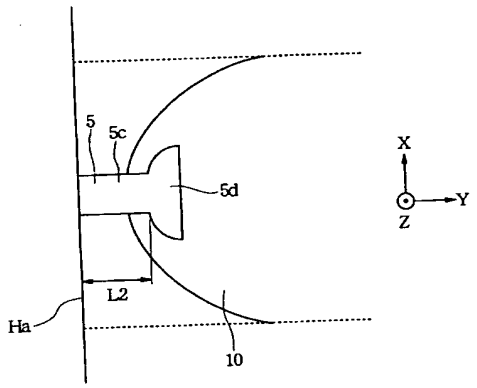
【図２９】

図29



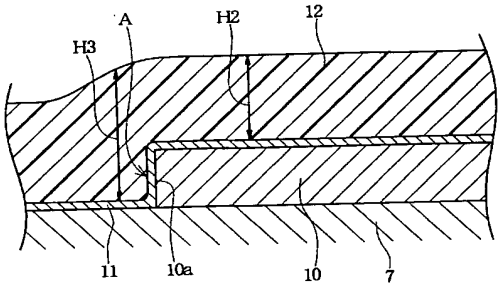
【図３０】

図30



【図３１】

図31



【図３２】

図32